

VANGUARD®



REPAIR MANUAL

Vanguard® BIG BLOCK™
Diagnostic and Repair

M540000/M610000



Foreword

This manual was written to assist engine technicians and service personnel with the maintenance and repair procedures for Briggs & Stratton® engines. It assumes that persons using this manual have been properly trained and are familiar with the service procedures for these products, including the proper use of required tools and the application of appropriate safety practices. Persons untrained or unfamiliar with these procedures or products should not attempt to perform such work.

Proper maintenance and repair is important to safe, reliable operation of all engines and engine-driven systems. The maintenance, troubleshooting, and repair procedures described in this manual are appropriate for the Briggs & Stratton engines described herein. Alternative methods or procedures may pose risks to both personal safety and engine reliability and are not endorsed or recommended by Briggs & Stratton.

All information, illustrations, and specifications contained in this manual were based on the data available at the time of publication. Briggs & Stratton reserves the right to change, alter, or otherwise improve the product or the product manuals at any time without prior notice.

Briggs & Stratton offers two complementary publications to enhance understanding of engine technology, maintenance, and repair. However, neither publication is a substitute for a recognized training program for engine technicians.

- For consumers, *Small Engine and Equipment Maintenance Guide* (Part No. CE8155) provides a comprehensive overview of how small air-cooled engines work, basic troubleshooting, and step-by-step maintenance procedures.
- For engine technicians and consumers alike, an in-depth study of engine theory and operation can be found in the textbook *Small Engines* (Part No. CE8020).

Both publications can be purchased at www.briggsandstratton.com or through a local Briggs & Stratton Authorized Service Dealer.

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Engine Models Covered

This engine repair manual includes the following engine models:

- MODEL 540000
- MODEL 610000

NOTE: Some models have limited service parts. Review the *Illustrated Parts List* for part availability before conducting any service work.

NOTE: Many of the images in this document are representative of the Horizontal-shaft EFI-ETC engine. While other engines models may appear somewhat different, unless indicated otherwise, the procedures are the same.

How To Use This Manual

Besides describing the service maintenance tasks and the intervals at which they are to be performed, three basic levels of service are presented in this manual: troubleshooting problems with the engine, engine top end service, and engine bottom end service. The manner in which these instructions are used depends upon the tasks to be performed and the level of disassembly and servicing required.

Troubleshooting And Special Tools

When diagnosing a specific problem with an engine or engine component, first see *SECTION 3 - TROUBLESHOOTING AND SPECIAL TOOLS*. This section is designed to be used as a guide for diagnostics on the engine. This section provides potential problem scenarios, potential causes for those problems, and action items to help with the repair. The section also provides a list of Special Tools that are either useful or required in the diagnostics, service, and repair of the engine.

Remove External Assemblies

To prepare the engine for service, whether top or bottom end, first see *SECTION 4 - REMOVE EXTERNAL ASSEMBLIES* to remove the muffler, air cleaner, etc. The order in which the topics are presented is the order in which the assemblies are most easily removed from the engine.

Top End Service

If servicing only cylinder head components, see *SECTION 5 - DISASSEMBLE ENGINE, TOP END DISASSEMBLY*, and then proceed to *SECTION 6 - SERVICE ENGINE SUBASSEMBLIES, CYLINDER HEAD*. When cylinder head service is complete, see *SECTION 7 - ASSEMBLE ENGINE, TOP END ASSEMBLY*.

Bottom End Service

If servicing bottom end components, such as the piston, connecting rod, crankshaft, etc., first see *SECTION 5 - DISASSEMBLE ENGINE, TOP END DISASSEMBLY*, and then proceed to *BOTTOM END DISASSEMBLY* in the same section. When finished, move to *SECTION 6 - SERVICE ENGINE SUBASSEMBLIES*, and see *PISTON AND CONNECTING ROD; FLYWHEEL, CRANKSHAFT AND CAMSHAFT*; and *CRANKCASE AND CRANKCASE COVER*, for all service instructions. When bottom end service is complete, see *SECTION 7 - ASSEMBLE ENGINE, BOTTOM END ASSEMBLY*, and then proceed to *TOP END ASSEMBLY* in the same section.

Install External Assemblies

When the top and bottom ends of the engine are assembled, see *SECTION 8 - INSTALL EXTERNAL ASSEMBLIES* to complete the project. The order in which the topics are presented is the order in which the assemblies are most easily installed on the engine. These instructions also include any cleaning, inspection, or adjustments that may be recommended.

Specifications

The final section of this manual, *SECTION 9 - SPECIFICATIONS* provides engine specifications, acceptable component wear measurements, and torque specifications for the engine. While specifications for components to be serviced are listed within the manual, a comprehensive list is also provided for quick reference.

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SAFETY INFORMATION

Safety Alert Symbol and Signal Words

The safety alert symbol  identifies safety information about hazards that could result in personal injury. A signal word (**DANGER**, **WARNING**, or **CAUTION**) is used to indicate the likelihood and the potential severity of injury. In addition, a hazard symbol is used to represent the type of hazard.











DANGER indicates a hazard which, if not avoided, **will** result in death or serious injury.

WARNING indicates a hazard which, if not avoided, **could** result in death or serious injury.

CAUTION indicates a hazard which, if not avoided, **could** result in minor or moderate injury.

NOTICE indicates information considered important but not hazard-related.

Hazard Symbols and Meanings

	Safety information about hazards that can result in personal injury.		Read and understand the Operator's Manual before operating or servicing the unit.
	Fire Hazard		Explosion Hazard
	Shock Hazard		Toxic Fume Hazard
	Hot Surface Hazard		Kickback Hazard
	Amputation Hazard - Moving Parts		Fuel Level - Maximum Do Not Overfill

General Safety Messages

Prior to work, read and understand the section(s) of this manual that pertain to the job. Follow all safety warnings.

- Always use fresh gasoline. Stale fuel can cause gum deposits in the carburetor and cause leakage, flow restrictions, or other problems.
- Check fuel lines and fittings frequently for cracks or leaks and replace if necessary.

WARNING

Failure to read and obey the operator's manual, all warnings, and operating instructions could result in death or serious injury.

WARNING

Briggs & Stratton® Engines are not designed for and are not to be used to power: fun-karts; go-karts; children's, recreational, or sport all-terrain vehicles (ATVs); motorbikes; hovercraft; aircraft products; or vehicles used in competitive events not sanctioned by Briggs & Stratton. For information about competitive racing products, see www.briggsracing.com. For use with utility and side-by-side ATVs, please contact Briggs & Stratton Power Application Center, 1-866-927-3349. Incorrect engine use could result in serious injury or death.

WARNING

Fuel and its vapors are flammable and explosive. Fire or explosion could result in burns or death.

When you add fuel

- Stop the engine. Before you remove the fuel cap, wait a minimum of two (2) minutes to make sure that the engine is cool.
- Fill the fuel tank outdoors or in an area that has good airflow.
- Do not put too much fuel in the tank. For expansion of the fuel, do not fill above the bottom of the fuel tank neck.
- Keep fuel away from sparks, open flames, pilot lights, heat, and other ignition sources.
- Frequently examine the fuel lines, fuel tank, fuel cap, and connections for cracks or leaks. Replace damaged parts.
- If fuel spills, wait until it dries before you start the engine.

When you start the engine

- Make sure that the spark plug, muffler, fuel cap and air cleaner (if equipped) are correctly installed.
- Do not crank the engine with the spark plug removed.
- If the engine is flooded, set the choke (if equipped) to the OPEN or RUN position. Move the throttle (if equipped) to the FAST position and crank until the engine starts.
- If there is natural or LP gas leakage in the area, do not start the engine.
- Because vapors are flammable, do not use pressurized starter fluids.

When you operate the equipment

- Do not tilt the engine or the equipment at an angle which causes fuel to spill.
- Do not choke the carburetor (if equipped) to stop the engine.
- Do not start or operate the engine with the air cleaner (if equipped) or the air filter (if equipped) removed.

When you do maintenance

- If you drain the oil from the top oil fill tube, the fuel tank must be empty. If it is not empty, fuel leakage can occur and could result a fire or an explosion.

- During maintenance if it is necessary to tilt the unit, make sure that the fuel tank, if mounted on the engine, is empty and that the spark plug side is up. If the fuel tank is not empty, leakage can occur and could result a fire or an explosion.
- Frequently examine the fuel lines, fuel tank, fuel cap, and connections for cracks or leaks. Replace damaged parts.
- Do not change the governor spring, links or other parts to increase engine speed.
- Do not hit the flywheel with a hammer or hard object. This could result in failure of the flywheel during operation.
- Replacement parts must be of the same design and installed in the same position as the original parts. Other parts could result in damage or an injury.

When you move the location of equipment

- Make sure that the fuel tank is EMPTY or that the fuel shut-off valve is in the CLOSED position.

When fuel or equipment is in storage with fuel in the fuel tank

- Because pilot lights or other ignition sources can cause explosions, keep fuel or equipment away from furnaces, stoves, water heaters or other appliances that have pilot lights.



Fuel vapors are flammable and explosive. Fire or explosion could result in burns or death. Always observe the following safety precautions before removing any fuel system components:

- Wear eye protection.
- Relieve fuel system pressure.
- Make sure there are no open flames or potential ignition sources in the area.
- When removing a fuel hose or fitting, cover with a shop towel to catch and fuel leakage.
- Collect any fuel and/or shop towels in approved containers and dispose of properly.
- Make sure to keep dirt and debris out of fuel lines, injectors and fuel pumps.
- Keep a dry chemical fire extinguisher on hand in case of emergencies.



Fuel vapors are flammable and explosive. Fire or explosion could result in burns or death.

If you smell gas

- Do not start the engine.
- Do not switch on electrical switches.
- Do not use a phone in the vicinity.
- Evacuate the area.
- Contact the gas supplier or the fire department.



Fuel vapors are flammable and explosive. Fire or explosion could result in burns or death.

- Do not start and operate the engine with the air cleaner assembly (if equipped) or the air filter (if equipped) removed.



Fuel vapors are flammable and explosive. Fire or explosion could result in burns or death.

Engine start-up causes spark that could result in a fire or explosion.

- If there is natural or LP gas leakage in the area, do not start the engine.
- Because vapors are flammable, do not use pressurized starter fluids.



POISONOUS GAS HAZARD. Engine exhaust contains carbon monoxide, a poisonous gas that could kill you in minutes. Although you do not smell exhaust fumes, you could still be exposed to dangerous carbon monoxide gas. If you feel sick, dizzy, or weak while you use this product, get to fresh air RIGHT AWAY. See a doctor. You may have carbon monoxide poisoning.

- Carbon monoxide gas can collect in occupied spaces. To reduce the risk of carbon monoxide gas, ONLY operate this product outdoors and far away from windows, doors and vents.
- Install battery-operated carbon monoxide alarms or plug-in carbon monoxide alarms with battery back-up as specified by the manufacturer's instructions. Smoke alarms cannot sense carbon monoxide gas.
- DO NOT operate this product in homes, garages, basements, crawlspaces, sheds, or other closed spaces, even if you use fans or open doors and windows for ventilation. After the operation of this product, carbon monoxide can quickly collect in these spaces and stay for hours.
- ALWAYS put this product downwind and point the engine exhaust away from occupied spaces.



During operation, the engine and muffler become hot. If you touch a hot engine, thermal burns can occur.

Combustible materials, such as leaves, grass and brush, can catch fire.

- Before you touch the engine or muffler, stop the engine and wait two (2) minutes. Make sure that the engine and muffler are safe to touch.
- Remove debris from the muffler and engine.



WARNING

Accidental engine spark can cause an electric shock, fire or explosion and could result in entanglement, traumatic amputation or laceration.

Before you make adjustments or repairs:

- Disconnect all spark plug wires and keep them away from the spark plugs.
- Disconnect the battery wire from the negative battery terminal (only engines with electric start).
- Use only the correct tools.

When you check for spark:

- Use an approved spark plug tester.
- Do not check for spark with the spark plug removed.



WARNING

Rotating parts can entangle hands, feet, hair, clothing, or accessories and result in traumatic amputation or laceration.

- Operate equipment with the guards correctly installed.
- Keep hands and feet away from rotating parts.
- Remove jewelry and make sure that long hair is away from all rotating parts.
- Do not wear loose clothes or items that could become caught.



WARNING

Fuel and its vapors are flammable and explosive. Fire or explosion could result in burns or death.

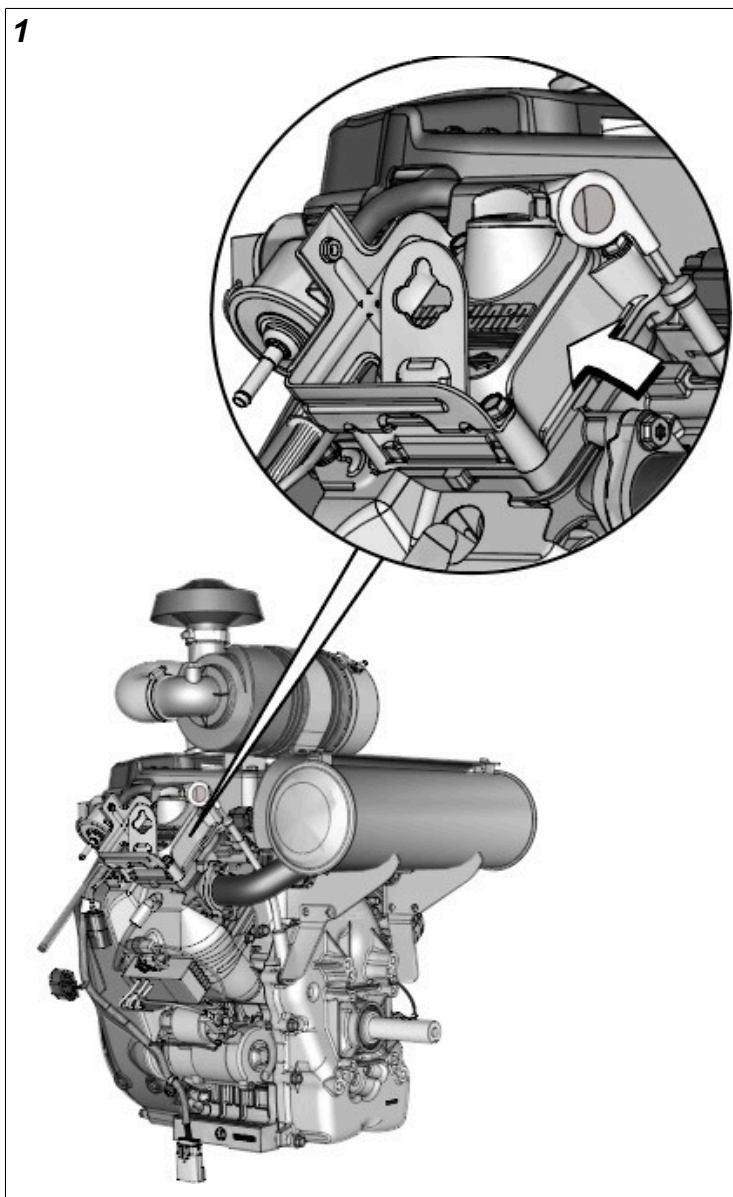
Fuel Storage

- Because pilot lights or other ignition sources can cause explosions, keep fuel or equipment away from furnaces, stoves, water heaters or other appliances that have pilot lights.

GENERAL INFORMATION

Engine Identification

See Figure 1. On horizontal shaft engines, the engine model, type, trim and serial number are etched on the oil fill valve cover on the starter motor side of the engine. Vertical shaft engines may have the model, type, trim and serial number etched on the valve cover on the oil filter side of the engine. Older Big Block engines may have the model, type, trim and serial number etched on the base of the crankcase. Additionally, a Power Code decal, mounted on the engine blower housing, provides the serial number, model number, and a QR code for easy access to the Power Portal.



Fuel Recommendations

Fuel must meet these requirements:

- Clean, fresh, unleaded gasoline.
- A minimum of 87 octane/87 AKI (91 RON). High altitude use, see below.

- Gasoline with up to 10% ethanol (gasohol) is permitted.

NOTICE

Do not use unapproved gasoline, such as E15 and E85. Do not mix oil in gasoline or change the engine to operate on alternate fuels. Use of unapproved fuels could result in damage to engine components, which will not be repaired under the warranty.

To protect the fuel system from gum formation, and corrosion, mix an alcohol-free fuel stabilizer and ethanol treatment into the fuel. Refer to the **Storage** section. All fuel is not the same. If start or performance problems occur, change fuel providers or brands. This engine is certified to operate on gasoline. The emissions control system for carbureted engines is EM (Engine Modifications). The emissions control systems for engines with electronic fuel injection are ECM (Engine Control Module), MFI (Multiport Fuel Injection), TBI (Throttle Body Fuel Injection) and if equipped an O2S (Oxygen Sensor).

High Altitude

At altitudes over 5,000 feet (1524 meters), a minimum 87 octane/87 AKI (91 RON) gasoline is permitted.

For carbureted engines, high altitude adjustment is required to maintain performance. Operation without this adjustment will cause decreased performance, increased fuel consumption, and increased emissions. Contact a Briggs & Stratton Authorized Service Dealer for high altitude adjustment information. Operation of the engine at altitudes below 2,500 feet (762 meters) with the high altitude adjustment is not recommended.

For Electronic Fuel Injection (EFI) engines, no high altitude adjustment is necessary.

Fuel Recommendations - Gaseous Engines

Fuel must meet these requirements

- Use clean, dry fuel, free of moisture or any particulate material. Fuels used outside the recommended values can cause performance problems.
- On engines that operate on LPG, commercial grade HD5 LPG is recommended. Recommended fuel composition is fuel with a minimum fuel energy of 2500 BTU's/ft³ with maximum propylene content of 5% and butane and heavier gas content of 2.5% and minimum propane content of 90%.

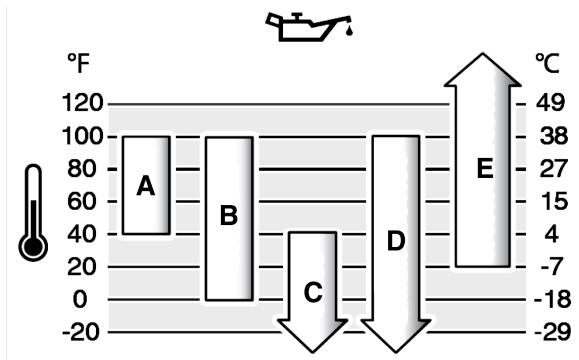
NG or LPG engines are certified to operate on natural or liquid propane gas. The emissions control system for this engine is EM (Engine Modifications).

Oil Recommendations

Oil Capacity: Refer to *SECTION 9 - SPECIFICATIONS*.

We recommend the use of Briggs & Stratton® Warranty Certified oils for best performance. Other high-quality detergent oils are permitted if classified for service SF, SG, SH, SJ or higher. Do not use special additives.

Use the chart to select the best viscosity for the outdoor temperature range expected. Vanguard® 15W-50 Synthetic oil gives the best protection in most environments as well as superior protection for equipment operated in hot temperatures. Engines on most outdoor power equipment can operate well with Synthetic 5W-30 oil.



A	SAE 30 - Below 40 °F (4 °C) the use of SAE 30 will result in hard starting.
B	10W-30 - Above 80 °F (27 °C) the use of 10W-30 may cause increased oil consumption. Check the oil level frequently.
C	5W-30
D	Synthetic 5W-30
E	Vanguard® Synthetic 15W-50

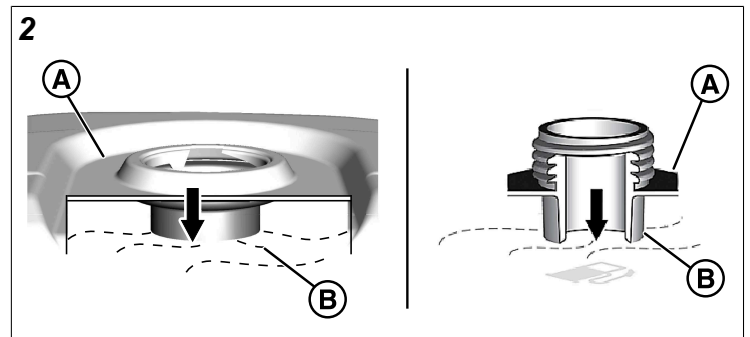
Fuel Storage

Keep the engine level at the correct operating position. Fill the fuel tank (**A**, Figure 2) with fuel. For fuel expansion, do not fill above the fuel tank neck (**B**).

Fuel can become stale when kept in a storage container for more than 30 days. The use of an alcohol-free fuel stabilizer and ethanol treatment in the fuel storage container is recommended. This keeps fuel fresh and decreases fuel-related problems or contamination in the fuel system.

If gasoline in the engine has not been treated with a fuel stabilizer, it must be drained into an approved container. Operate the engine until it is out of fuel.

NOTE: DO NOT run the Electronic Fuel Injection engine out of fuel. Fuel pump damage can occur. Make sure to add the correct amount of fuel stabilizer to the fuel tank, and run the engine for 30 minutes.



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Maintenance Schedule

After First 5 Hours
<ul style="list-style-type: none"> • Change Engine Oil +
Every 8 Hours or Daily
<ul style="list-style-type: none"> • Check Engine Oil Level + • Clean Area Around Muffler and Controls
Every 100 Hours or Annually
<ul style="list-style-type: none"> • Change Engine Oil and Replace Oil Filter + • Clean or Replace Air Filter † ‡ • Clean/Gap/Replace Spark Plugs • Clean/Inspect Muffler and Spark Arrester, if equipped
Every 250 Hours or Annually
<ul style="list-style-type: none"> • Check/Adjust Valve Clearance
Every 400 Hours or Annually
<ul style="list-style-type: none"> • Replace Air Filter ‡ • Replace Fuel Filter • Clean Air Cooling System †
Every 500 Hours or Annually
<ul style="list-style-type: none"> • Change Engine Oil and Replace Oil Filter ÷
Every 600 Hours
<ul style="list-style-type: none"> • Replace Safety Filter *

+ Engines not equipped with the Vanguard Oil Guard System.

÷ Engines equipped with the Vanguard Oil Guard System.

† Clean more often in dusty conditions or when airborne debris is present.

‡ All engines.

* If equipped, replace the safety filter every 600 hours or every third air filter replacement.

Preliminary Instructions

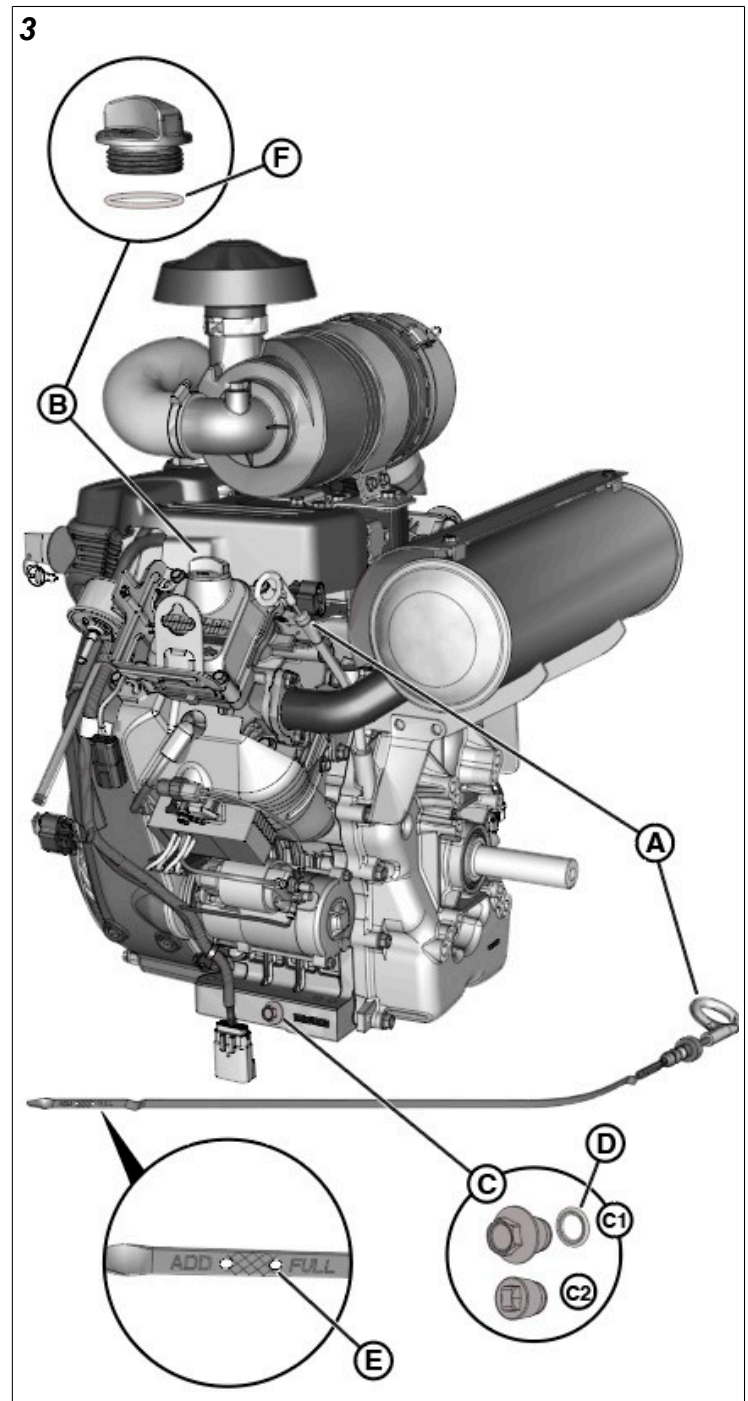
Prior to starting any repair or maintenance operation. Make sure you are familiar with ALL safety warnings and procedures as outlined in *SECTION 1 - SAFETY AND GENERAL INFORMATION - Safety Information*.

ALWAYS wear safety glasses and gloves while performing any maintenance and repair operation.

Check Engine Oil Level/Change Engine Oil/Replace Oil Filter

1. Place engine on a flat, level surface.
2. Remove spark plug wires from spark plug terminals. Secure spark plug wires to prevent unintentional contact with spark plug terminals.
3. Remove all dirt and debris from around the dipstick tube.

4. Remove dipstick (A, Figure 3) and wipe with a clean, lint free cloth.



NOTE: Proceed to step 12 if only checking engine oil level.

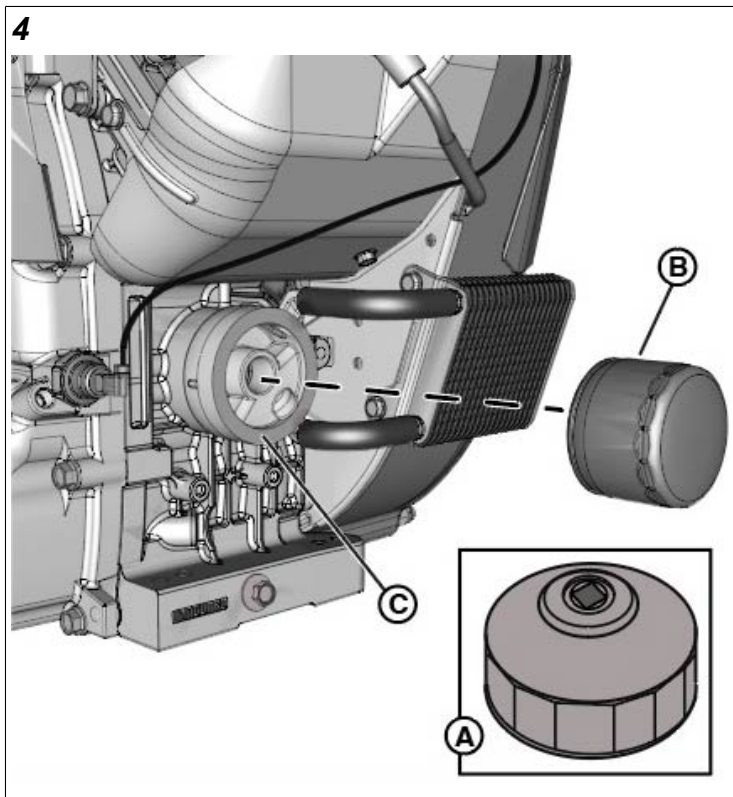
5. Remove oil fill cap (B) from valve cover.
6. Remove oil drain plug(s) (C) at base of engine and drain oil into an approved container.
7. If equipped, inspect drain plug O-rings (D) for damage or general deterioration. Replace if necessary.

8. Install oil drain plug(s) (**C1** or **C2**) and tighten as follows:

Oil Drain Plug		
Engine	Plug Type	Torque
Horizontal and Vertical Shaft	Metric (C1 in Figure 3)	240 lb-in (27.1 Nm)
	NPTF (C2 in Figure 3)	128 lb-in (14.5 Nm)
Oil Guard Equipped Engine, Drain Plug Installed on Crankcase Cover	NPTF (C2 in Figure 3)	125 lb-in (14.1 Nm)

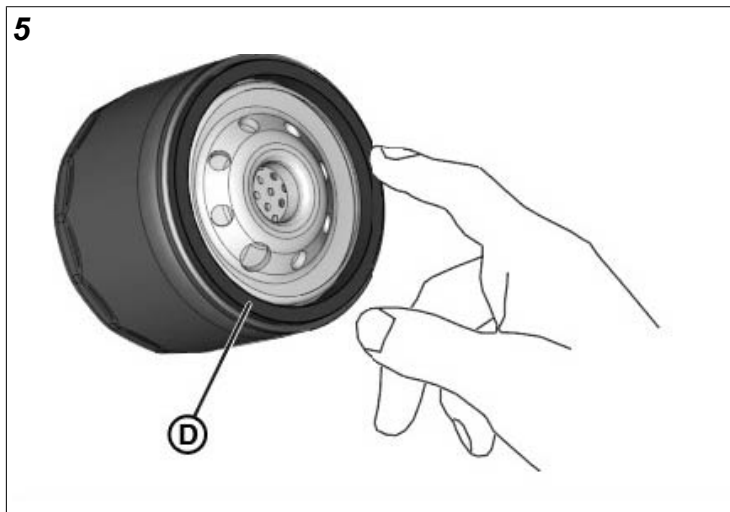
9. Remove oil filter as follows:

- Using a 76mm-14 Flute end cap style oil filter wrench (**A**, Figure 4) with ratchet and extension bar, turn oil filter (**B**) in a counterclockwise direction until loose, and then remove by hand. Do not use air tools.
- Clean the oil filter mount flange (**C**) of any old gasket material.



10. Install oil filter as follows:

- Verify the oil filter mount flange is clean and dry.
- Lubricate gasket of **new** oil filter with a thin film of clean engine oil (**D**, Figure 5).
- Install oil filter, and hand tighten until gasket just contacts filter mount flange. Using a 76mm-14 Flute end cap style oil filter wrench (**A**, Figure 4) with ratchet and extension bar, tighten oil filter to **75 lb-in** (8.5 Nm). Do not use air tools.



11. See Figure 3. Slowly pour the recommended type of oil into the valve cover opening. See *SECTION 1 - SAFETY AND GENERAL INFORMATION - General Information - Oil Recommendations*. DO NOT overfill.

Oil Capacity	
Models	Capacity
540000	78-80 oz (2.3-2.4 L)
610000	78-80 oz (2.3-2.4 L)

- Allow a few seconds to elapse to allow oil to drain to the crankcase.
- Slowly insert dipstick until it bottoms in the dipstick tube.

NOTE: The most accurate oil level readings are obtained when the engine is cold.
- Slowly remove dipstick.
- Verify that oil level is on the cross hatch pattern at or near the FULL mark (**E**, Figure 3).

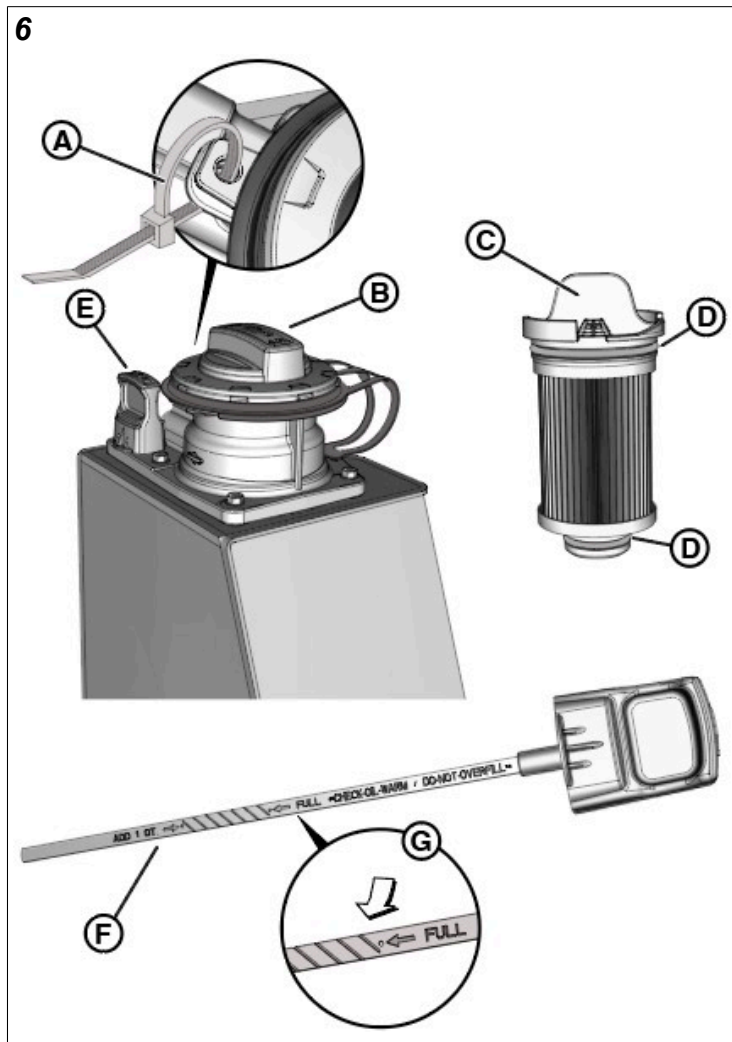
NOTE: Observe oil level on both sides of the dipstick. The lower level of the two readings is the correct oil level measurement.
- Add oil as necessary until oil level is correct.
- Install dipstick into dipstick tube.
- Inspect oil fill cap O-ring (**F**) for damage or signs of deterioration. Replace if necessary.
- Install oil fill cap into valve cover. Tighten oil fill cap securely, but do not over-tighten.
- Install spark plug wires onto spark plug terminals.

21. Start and run engine for one minute. Check for oil leaks while engine is running.
22. Dispose of used oil and oil filter at a proper waste disposal or recycling center.

Check/Change Engine Oil/Replace Oil Filter on Vanguard® Oil Guard™ System

NOTE: After every 8 running hours, check reservoir oil level as described in step 16.

1. Place engine on a flat, level surface.
2. Start and run engine until it reaches normal operating temperature. Stop engine.
3. Remove spark plug wires from spark plug terminals. Secure spark plug wires to prevent contact with spark plug terminals.
4. If present, cut cable strap (A, Figure 6) or remove other locking device to release oil fill cap from oil filter housing.



5. Rotate oil fill cap (B) ¼ turn to unlock. Remove cap from filter housing.
6. Remove oil drain hose from retaining clip.

7. Rotate drain hose cap ¼ turn to unlock. Remove cap and drain oil into an approved container.

NOTE: Your engine may be equipped with an optional oil drain valve in place of the oil drain hose. To drain the oil, open the valve and allow the oil to empty into an approved container for disposal.

8. Grasp tab and rotate oil filter (C) ¼ turn to unlock. Remove oil filter from filter housing.

NOTE: It is necessary to overcome the resistance of two o-rings (D) to free oil filter from filter housing.

9. Install cap onto oil drain hose and rotate ¼ turn to lock. Capture hose in retaining clip.
10. Apply light film of clean engine oil to top and bottom o-rings of new oil filter.
11. Install oil filter into filter housing and rotate ¼ turn to lock.
12. Slowly add **5 quarts** (4.7 L) of the recommended type of oil. See *SECTION 1 - SAFETY AND GENERAL INFORMATION - General Information - Oil Recommendations*. DO NOT overfill.

NOTE: A screened opening at the top of the oil filter allows oil to be added with the filter installed. Oil can be added with the filter removed, but exercise care to ensure that the oil supply is not contaminated by dust, dirt, or debris.

13. Install oil fill cap and rotate ¼ turn to lock.
14. Install spark plug wires onto spark plug terminals.
15. Dispose of used oil and oil filter at a proper waste disposal or recycling center.

Check Oil Guard Oil Level

To check the Oil Guard reservoir oil level, proceed as follows:

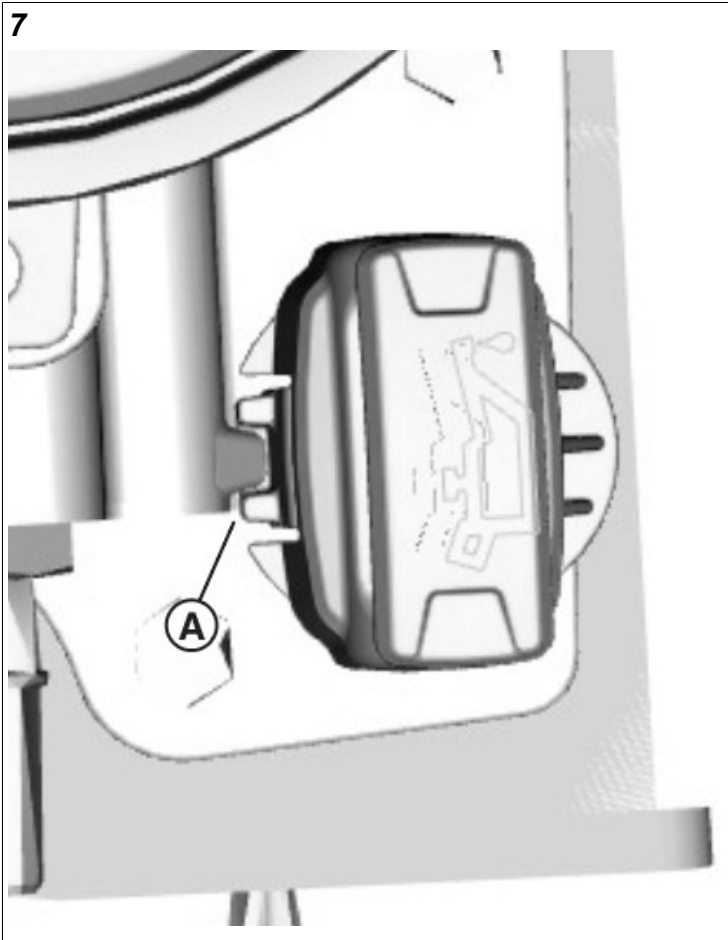
NOTE: For best results, check oil level when oil is warm.

1. Verify that oil reservoir is on a flat, level surface.
2. Remove all dirt and debris from around the dipstick cap (E).
3. Remove dipstick (F) by pulling straight up. Wipe with a clean, lint free cloth.
4. Insert dipstick until it bottoms in the reservoir.
5. Slowly remove dipstick. Verify that oil level is on the cross hatch pattern at or near the FULL mark (G).

NOTE: Observe oil level on both sides of the dipstick. The lower level of the two readings is the correct oil level measurement.

6. Remove oil fill cap and add oil as necessary until oil level is correct.

7. Install dipstick.



NOTE: One side of the dipstick cap has a tab that is designed to locate the dipstick in the correct orientation in the oil tank. This dipstick tab is to be centered on the oil tank casting tab (A, Figure 7). The dipstick must be mounted in this orientation to prevent sticking and false oil level readings.

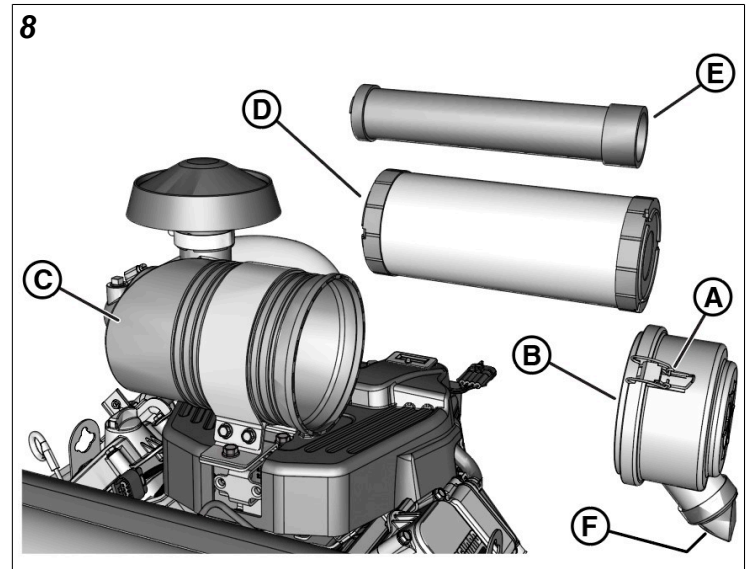
8. Install oil fill cap.

NOTE: With the oil fill cap in the lock position, holes in the cap and oil filter housing are aligned. Install cable strap or other locking device to prevent accidental cap removal, if desired (A, Figure 6).

Clean/Replace Air Filter/Safety Filter

1. Disengage two retaining clips (A, Figure 8) to release air cleaner cover (B) from air cleaner base (C).
2. Remove air filter (D) from air cleaner base.
3. Remove safety filter (E) from air cleaner base, if equipped.

4. Gently tap air filter on a hard surface to remove dust, dirt and debris. Carefully brush and/or vacuum air filter as necessary.



NOTE: Use of pressurized air or solvents will damage air filter.

5. Carefully inspect air filter, and replace if it cannot be adequately cleaned or if any damage is observed.
6. Inspect seal at air cleaner base (D) for cuts, tears, holes, or general deterioration. Replace as necessary.
7. Use a soft bristle brush and a portable hand vacuum to remove all dust and dirt from air cleaner cover and air cleaner base.

NOTE: Exercise care to keep dust and dirt out of hose to air intake elbow. Inadequate precautions can result in engine damage.

8. If equipped, install safety filter into air cleaner base. Orient the safety filter so that the open end installs into the base.

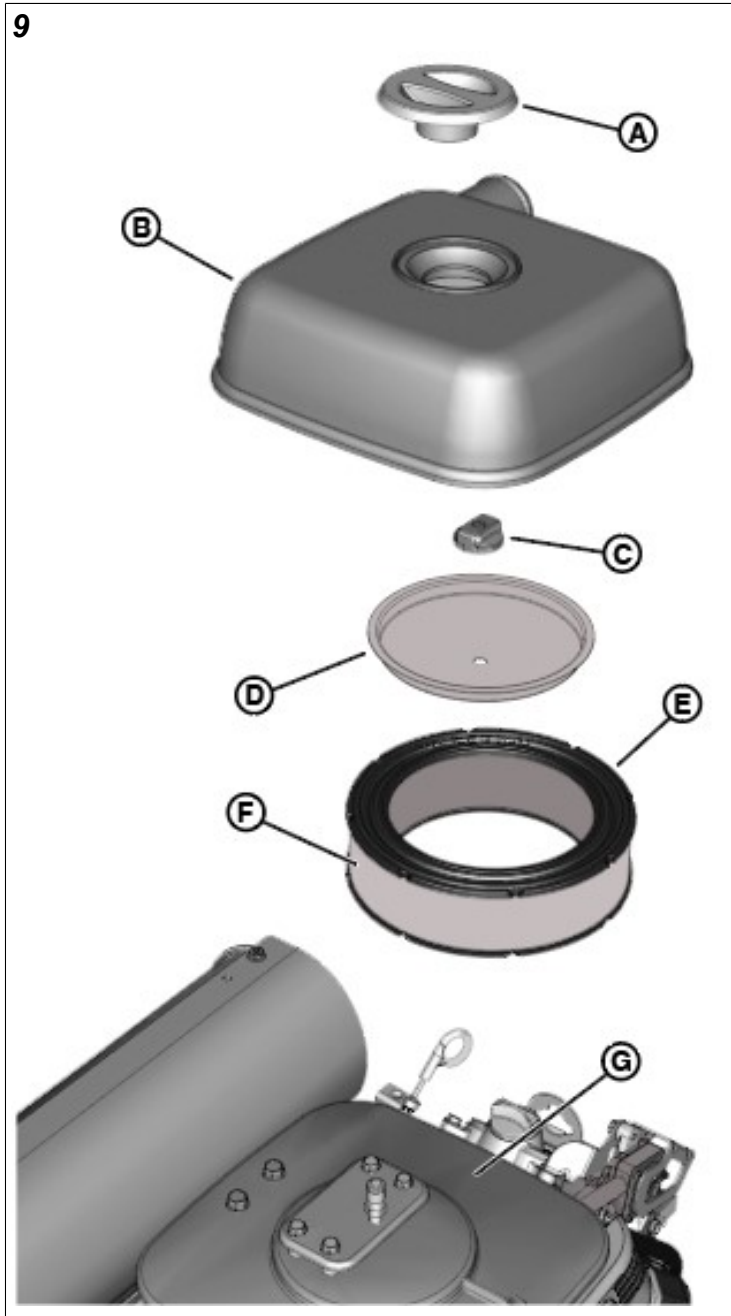
NOTE: Replace the safety filter with every third air filter replacement.

9. Install air filter into air cleaner base.
10. Install air cleaner cover onto air cleaner base and engage two retaining clips to secure.
11. Inspect duckbill air valve (F) on air inlet port of air cleaner cover. Look for cuts, tears, holes, or general deterioration. Replace duckbill air valve if damaged or missing.

IMPORTANT NOTE: Engine operation without the duckbill air valve (F) can reduce filter efficiency by as much as 50 percent.

Clean/Replace Air Filter - Low Profile

1. Remove plastic cap (A, Figure 9) to release air filter cover (B).



2. Remove thumb nut (C) from threaded rod.

NOTE: Inspect carefully. A thumb nut (C) that is loose, prior to disassembly, may indicate dirt ingress.

3. Remove metal retainer plate (D).
4. Remove air filter (E).
5. Remove foam pre-cleaner from air filter (F).

6. Gently tap air filter on a hard surface to loosen dirt and debris. Carefully clean with a soft bristle brush and a portable hand vacuum as necessary.

NOTE: Use of pressurized air or solvents will damage air filter.

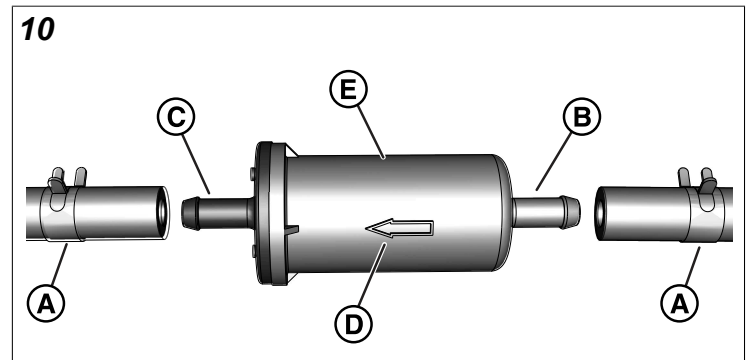
7. Use a soft bristle brush and a portable hand vacuum to remove all dust and dirt from air cleaner back plate (G), metal retainer plate, and air filter cover.

NOTE: Exercise care to keep dust and dirt out of air intake. Inadequate precautions can result in engine damage.

8. Gently wash foam pre-cleaner in warm, soapy water. Thoroughly rinse with clean water and allow to air dry completely.
9. Carefully inspect foam pre-cleaner and air filter. Replace parts if they cannot be adequately cleaned or if any damage is observed.
10. Install foam pre-cleaner onto air filter.
11. Place air filter onto air cleaner back plate.
12. Fit metal retainer plate evenly and snugly into air filter.
13. Install thumb nut onto threaded rod and tighten until snug.
14. Install air filter cover.
15. Install plastic cap to secure air filter cover and tighten until snug.

Replace Fuel Filter

1. Squeeze tangs and move hose clamps (A, Figure 10) away from fuel inlet (B) and outlet (C) fittings. Remove fuel inlet and outlet hoses from fuel filter fittings.

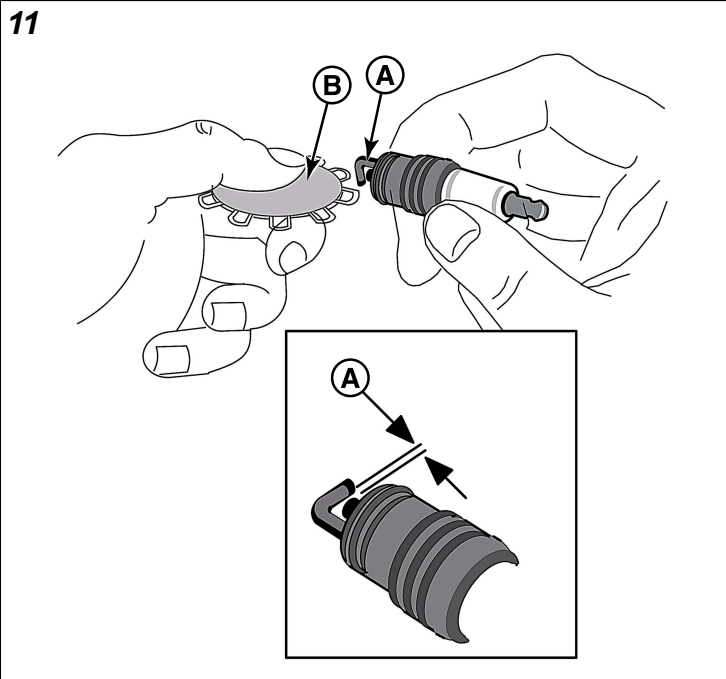


NOTE: Wrap shop towel around fuel filter fittings to catch any fuel leakage. Inspect fuel for water contamination.

2. With the arrow (D) pointing in the direction of fuel flow, install **new** fuel filter (E) between fuel inlet and outlet hoses. Squeeze tangs and move hose clamps about **1/8 inch** (3 mm) from end of each hose.
3. Turn ignition switch ON for two seconds, and then OFF for 10 seconds. Turn the ignition switch back to ON and check for fuel leaks.

Clean/Gap/Replace Spark Plug

1. Remove spark plug wire from spark plug terminal.
2. Thoroughly clean area around spark plug to keep dirt and debris out of combustion chamber.
3. Remove spark plug from cylinder head using a 5/8 inch spark plug wrench.
4. Check condition of threads in cylinder head. If necessary, soften deposits with penetrating oil and clean out with a thread chaser.
5. Clean spark plug using a wire brush and commercial solvent. Do not bead blast spark plug. Obtain **new** spark plug if electrode is pitted, burned, worn down or worn unevenly. Inspect porcelain for cracks and damage.
6. Using a feeler gauge (**B**, Figure 11), verify spark plug gap (**A**) is **0.030 in** (0.76 mm) for gasoline-fueled engines and **0.020 in** (0.51 mm) for gaseous-fueled engines. If necessary, adjust gap by carefully bending ground electrode.

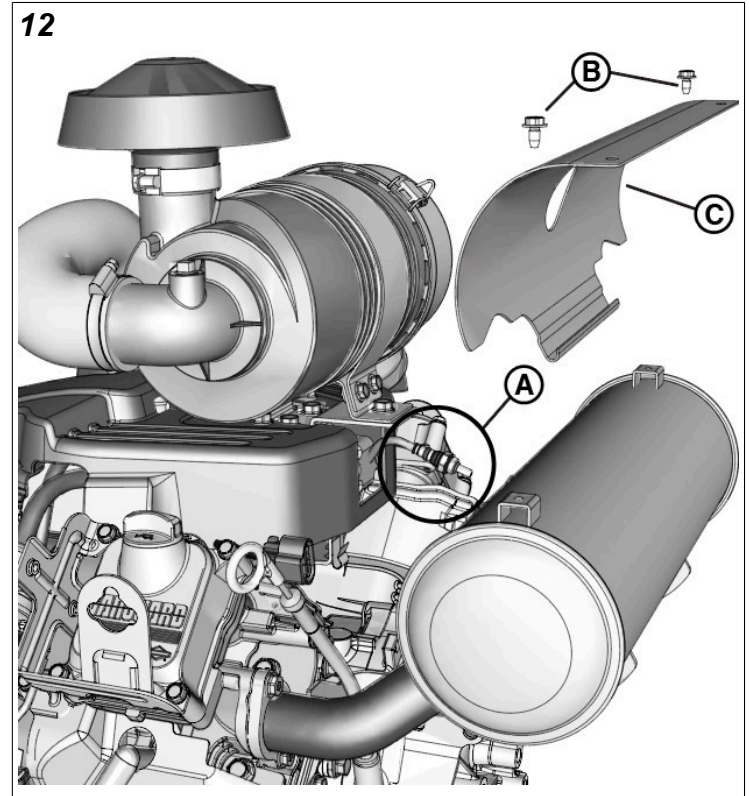


7. Finger tighten spark plug into cylinder head, and then tighten to **170 lb-in** (19.2 Nm).
8. Install spark plug wire onto spark plug terminal.

Clean/Inspect Muffler

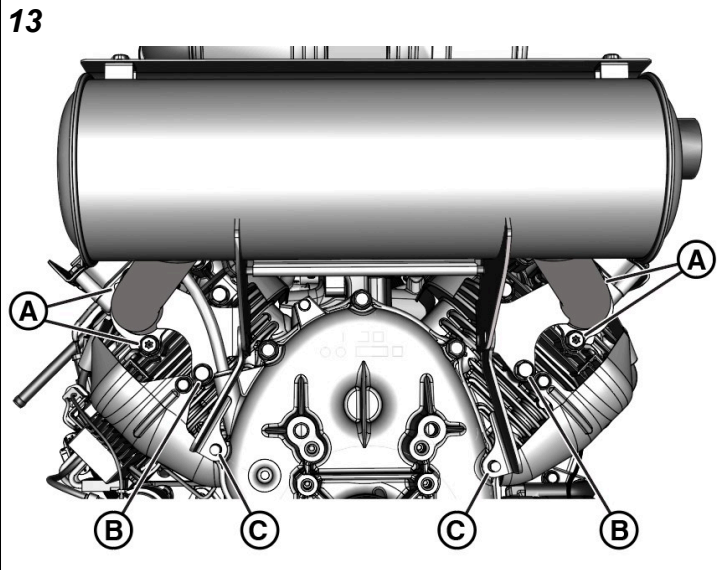
1. Remove spark plug wires from spark plug terminals. Secure spark plug wires to prevent contact with spark plug terminal.

2. Remove the oxygen sensor (**A**, Figure 12) from the muffler. Take care to avoid damaging the sensor wires.



3. Remove the 2 fasteners (**B**) to release heat shield (**C**) from muffler.
4. Clean area around and behind muffler. Proceed as follows:
 - A. Remove all loose debris by hand.
 - B. Remove dust and dirt with a soft bristle brush and a portable hand held vacuum.
 - C. Gently scrape away stubborn accumulations of dirt and other deposits using a plastic putty knife or stiff bristle brush.
 - D. Apply a light solvent to bristle brush to loosen and remove grit and oily residue, if necessary.
5. Inspect muffler for holes, split seams, cracked welds, loose internal parts, corrosion, and other damage. Replace as necessary.
6. Inspect muffler manifold and mounting flanges for cracked welds, breakage, and other damage. Replace as necessary.
7. Install the heat shield on to the muffler and install the 2 heat shield fasteners. Tighten fasteners to **87 lb-in** (9.8 Nm).
8. Install the oxygen sensor (**A**) onto the muffler. Tighten to **160 lb-in** (18 Nm).

9. Verify that exhaust manifold to cylinder head screws (A, Figure 13) are tightened to **195 lb-in (22 Nm)**.

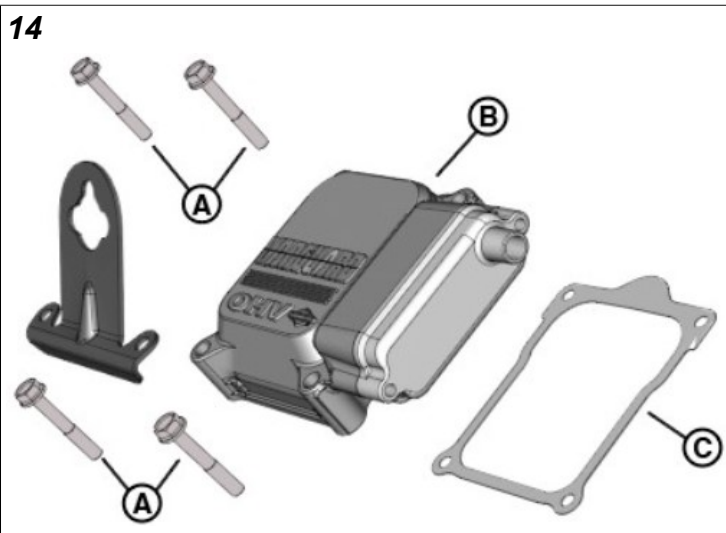


10. Verify that muffer bracket to cylinder screws (B) are tightened to **195 lb-in (22 Nm)**.
11. If equipped, verify that muffer support bracket nuts to crankcase cover studs (C) are tightened to **195 lb-in (22 Nm)**.
12. Install spark plug wires onto spark plug terminals.

Check/Adjust Valve Clearance

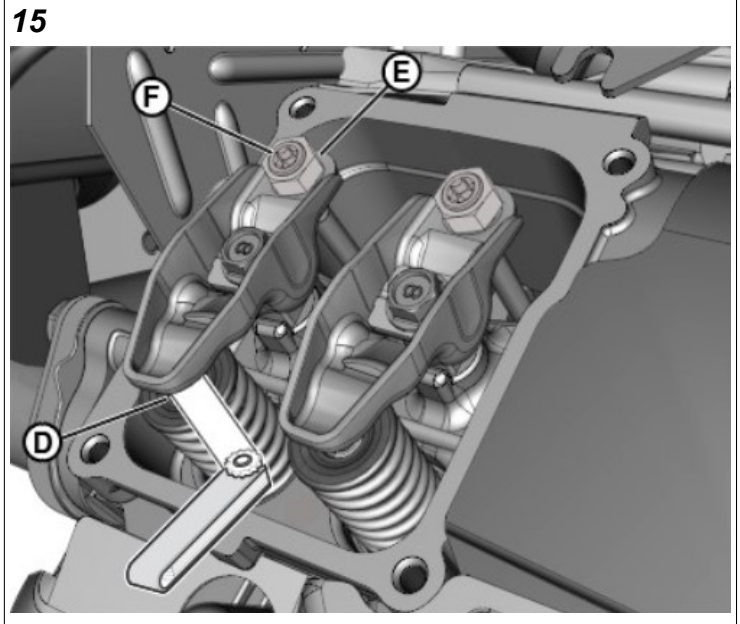
NOTE: Check valve clearance with the engine cold.

1. Remove spark plug wires from spark plug terminals.
2. Thoroughly clean area around spark plugs to keep dust and dirt out of the combustion chambers.
3. Remove spark plugs from cylinder heads. See *Check/Gap/Replace Spark Plug*.
4. Remove the 4 fasteners (A, Figure 14) to release valve covers (B) from cylinder heads.



5. Remove and discard valve cover gaskets (C).
6. Move the piston of the first cylinder to Top Dead Center (TDC) of the compression stroke. Proceed as follows:

- A. While rotating flywheel end of crankshaft by hand in the direction of engine rotation, watch the rocker arms to determine the action of the valves. After the exhaust valve closes, the intake valve begins to open.
 - B. When the intake valve closes (so that both valves are closed with the rocker arms loose), insert a wooden dowel through the spark plug hole until seated at the top of the piston.
 - C. Rotate engine in the same direction until the piston pushes the wooden dowel to its highest point. This is TDC of the compression stroke.
7. Insert feeler gauge between rocker arm and exhaust valve stem (D, Figure 15). Verify that exhaust valve clearance is **0.007-0.009 inches (0.18-0.23 mm)**.

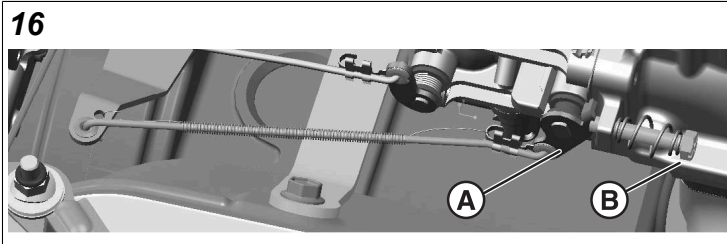


8. If adjustment is necessary, proceed as follows:
 - A. Obtain the Valve Adjustment Set. See *SECTION 3 - TROUBLESHOOTING - Special Tools List*.
 - B. Place 13 mm hex socket over lock nut (E).
 - C. Insert T-40 TORX bit through hole in socket tool to engage adjuster screw (F).
 - D. While holding adjuster screw to prevent rotation, loosen lock nut with socket, and then slightly turn adjuster screw in a clockwise or counter-clockwise direction (to either reduce or increase the valve clearance, respectively).
 - E. Holding adjuster screw to prevent rotation, rotate socket to tighten lock nut.
 - F. Remove tools and use feeler gauge to check valve clearance. Repeat steps as necessary until proper valve clearance is obtained.
 - G. Holding adjuster screw to prevent rotation, tighten lock nut to **105 lb-in (11.8 Nm)**. Check valve clearance one more time to verify that adjusting screw did not move when lock nut was tightened.

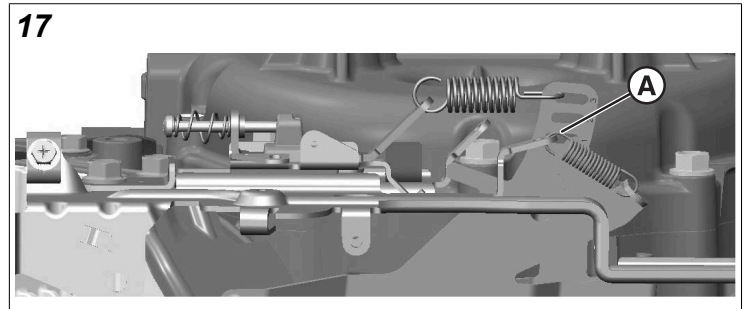
9. Insert feeler gauge between rocker arm and intake valve stem. Verify that intake valve clearance is **0.004-0.006 inches** (0.10-0.15 mm). If adjustment is necessary, see step 8.
10. Repeat steps 6-9 on opposite cylinder.
11. Rotate crankshaft 3 full turns to seat valve train.
12. Recheck valve clearance and adjust if necessary.
13. Remove old gasket material from valve covers and cylinder head flanges. Gasket material left on sealing surfaces will cause leaks.
14. Install **new** valve cover gaskets.
15. Install the valve covers to the cylinder heads along with any lifting bracket that was removed with the 4 valve cover fasteners. Tighten fasteners, using a diagonal tightening pattern, to **70 lb-in** (7.9 Nm).
16. Install spark plugs into cylinder heads and finger tighten until snug. Tighten spark plugs to **170 lb-in** (19.2 Nm).
17. Install spark plug wires onto spark plug terminals.

Idle Speed Adjustment - Mechanical Governor

1. Obtain a digital tachometer. See *SECTION 3 - TROUBLESHOOTING - Special Tools List*.
2. Follow the instructions included with the tachometer and connect to engine.
3. Start engine.
4. Hold the throttle lever (**A**, Figure 16) against the throttle stop adjustment screw (**B**).



5. Adjust the screw to bring the idle speed to the correct RPM based on the specification of the engine. See *The Power Portal* for correct idle speed RPM. Depending on the configuration of your engine, a governed idle spring may be present. If equipped, proceed as follows:
 1. Hold speed control against the low speed stop. Make sure that there is no tension on the high speed spring.
 2. Bend the low speed adjustment tab (**A**, Figure 17) until engine RPM is near the specified speed.
 3. Snap the throttle open and let the engine regain idle to ensure there is no friction within the system.

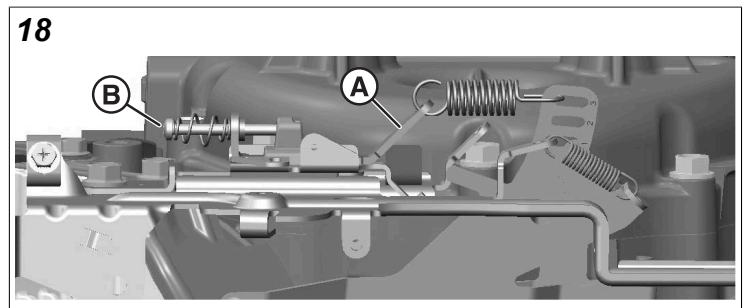


NOTE: If the idle speed is not specified, adjust to **1750 RPM**. If the engine has NO governed idle spring, and the idle speed is not specified, adjust idle to **1200 RPM**.

High Speed Adjustment - Mechanical Governor

1. Obtain a digital tachometer. See *SECTION 3 - TROUBLESHOOTING - Special Tools List*.
2. Follow the instructions included with the tachometer and connect to engine.
3. Start engine.
4. Hold the speed control against the high speed stop.
5. Bend the high speed adjustment tab (**A**, Figure 18) until the specified RPM is reached. See *The Power Portal* for correct high speed RPM.

NOTE: Some engines may be equipped with a high speed fine adjustment screw (**B**). This is used for fine adjustment of the top-no-load speed.



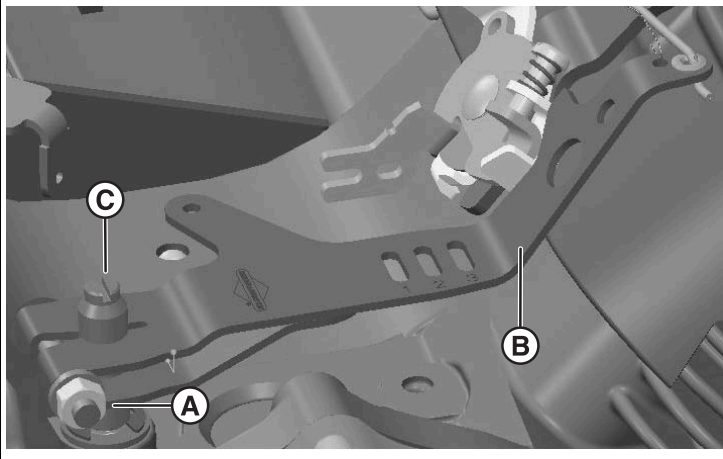
Static Governor Adjustment - Mechanical Governor

Complete the governor static adjustment BEFORE starting or running the engine. Incorrect adjustment may result in engine overspeeding.

NOTE: A static governor adjustment MUST be performed anytime any of the connecting components (carburetor, speed control bracket, linkages, etc) are removed, replaced or serviced.

1. Loosen the governor arm bracket bolt (A, Figure 19).

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2. Move the governor arm (B) until throttle is wide open.

NOTE: Do not bend governor link or governor lever.

3. Use a screwdriver to rotate the governor shaft (C) COUNTERCLOCKWISE as far as it will go.
4. While maintaining the governor shaft position, tighten the governor arm bracket pinch bolt to **135 lb-in** (15.3 Nm).

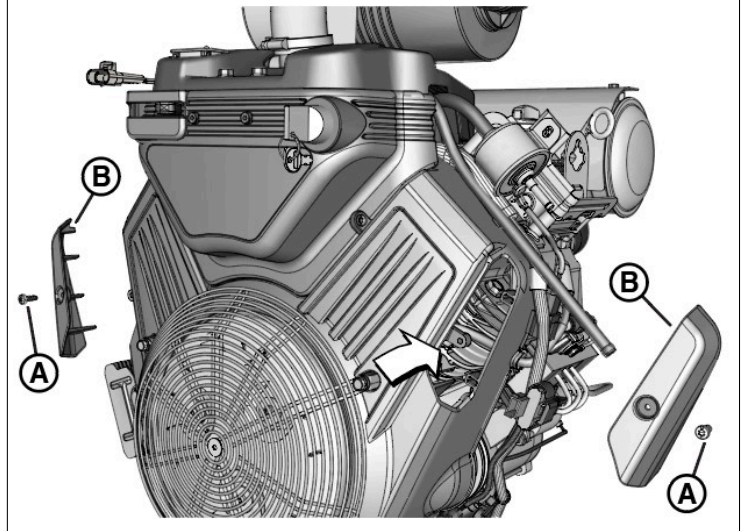
Clean Air Cooling System

NOTE: Avoid using high pressure compressed air, which can force dirt and debris deeper into engine cavities and crevices. Do not use a pressurized water spray as water intrusion can contaminate both oil and fuel systems and lead to corrosion.

1. Remove spark plug wires from spark plug terminals. Secure spark plug wires to prevent contact with spark plug terminal.

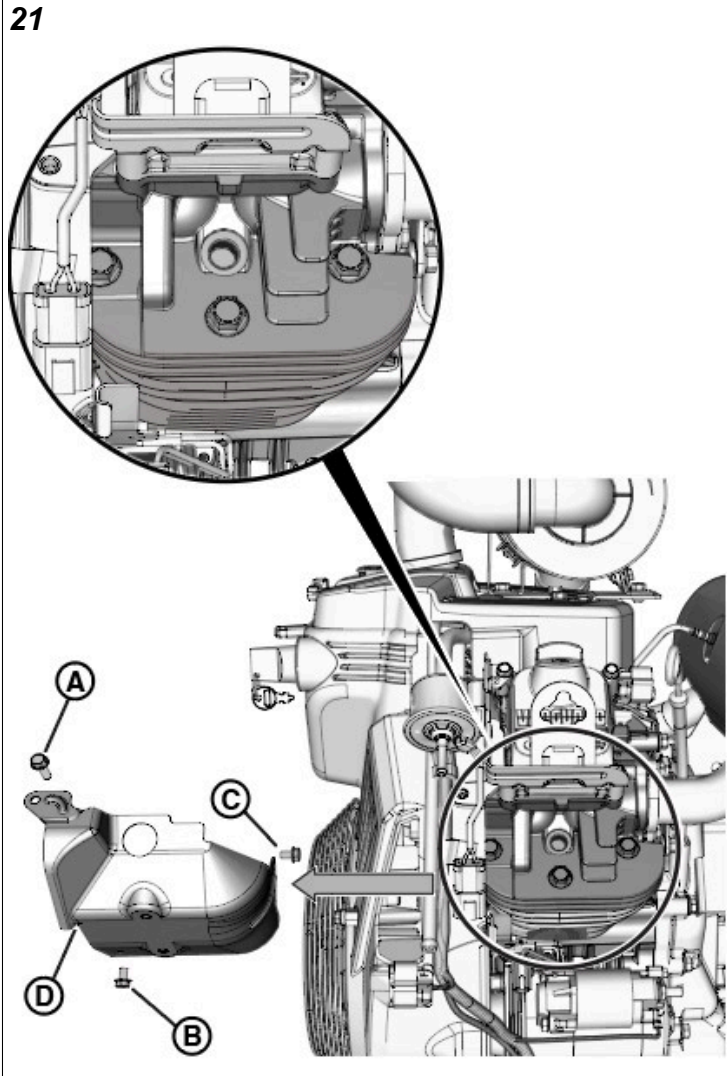
2. If equipped, remove the fasteners (A, Figure 20) to release the debris covers (B) on each side of the engine.

20



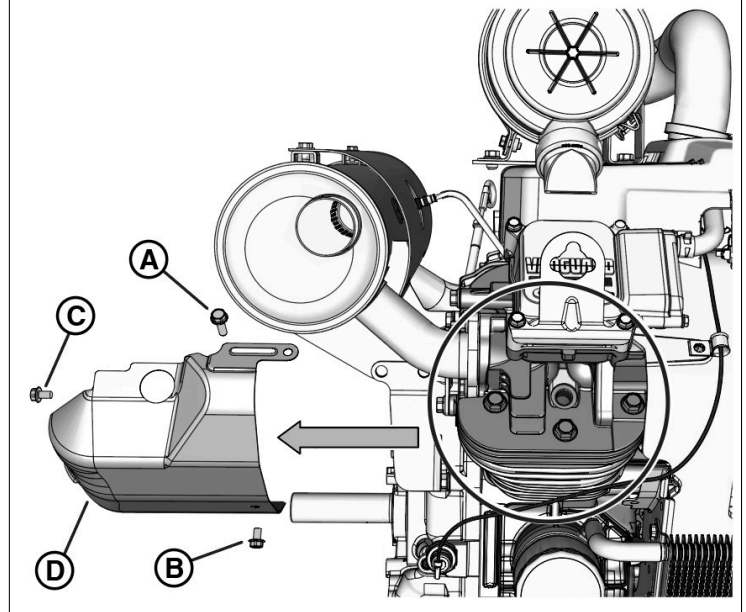
- Remove 3 fasteners to release air guide on starter motor side of engine. From front to back of engine, air guide screws are threaded into the intake manifold (A, Figure 21), back plate (B), and crankcase (C).

NOTE: Removal of the air guide screws may also release other parts, such as the blower housing and wire harness or hose clips. Take note of the location of these components, so that they may be properly captured when the screws are reinstalled.



- Remove 3 fasteners (A-C, Figure 22) to release air guide on oil filter side of engine.

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- Clean cylinder head and crankcase cooling fins as follows:

NOTE: Exercise care to keep dust and dirt out of air intake. Inadequate precautions can result in engine damage.

- Remove all loose debris by hand.
 - Remove dust and dirt with a soft bristle brush and a portable hand held vacuum.
 - Gently scrape away stubborn accumulations of dirt and other deposits using a plastic putty knife or stiff bristle brush.
 - Apply a light solvent to bristle brush to loosen and remove grit and oily residue, if necessary.
- Start 3 fasteners to install air guide on starter motor side of engine. From front to back of engine, air guide screws are threaded into the intake manifold (A, Figure 21), back plate (B), and crankcase (C).

NOTE: When the screws are installed, be sure to capture any other components, such as the blower housing and wire harness or hose clips noted at disassembly.

- Tighten air guide to intake manifold and back plate fastener to **90 lb-in** (10.2 Nm). Tighten air guide to crankcase fastener to **195 lb-in** (22 Nm).
- Start 3 fasteners (A-C, Figure 22) to install air guide on oil filter side of engine. Tighten the screws using the torque specifications in step 7.
- If equipped, install fasteners (A, Figure 20) to attach debris cover (B) to blower housing on each side of engine. Tighten fasteners to **30 lb-in** (3.4 Nm).
- Install spark plug wires onto spark plug terminals.

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TROUBLESHOOTING

General Complaints Most complaints concerning engine operation include one or more of the following:

- Will not start
- Hard starting
- Lack of power
- Runs rough
- Vibration
- Overheating
- High oil consumption

Equipment Check

What often appears to be a problem with the engine may actually be the result of faulty equipment.

No Start or Hard Start

- Loose belt or blade
- Cranking under heavy load
- Misadjusted controls
- Improperly operating oil pressure switch.

Engine Will Not Stop

- Equipment stop switch not functioning
- Engine ground wire damaged or disconnected

Vibration

- Bent cutter blades
- Loose spindles and couplings
- Bent/broken deck or weldments
- Bent crankshaft
- Loose equipment mounting bolts
- Damaged or worn belts and pulleys
- Out of balance impeller

Power Loss

- Bind or drag in moving parts of equipment
- Grass build-up under deck
- No lubrication in equipment gear box
- Excessive belt tension

Systems Check

Once equipment sources are ruled out, most symptoms can be traced to one or more of the following. Perform these checks in the order listed.

1. Ignition
2. Fuel System
3. Compression

Preliminary Instructions

Prior to starting any repair or maintenance operation. Make sure you are familiar with ALL safety warnings and procedures as outlined in *SECTION 1 - SAFETY AND GENERAL INFORMATION - Safety Information.*

ALWAYS wear safety glasses and gloves while performing any maintenance and repair operation.

Check Ignition System

1. If the engine cranks but does not start, move to step 2. If engine runs, but misses, move to step 9. Repeat testing steps on BOTH cylinders.

Engine Does Not Start

2. Verify that engine oil level is within the cross hatch pattern on the dipstick.
3. Obtain an Ignition Tester. See *Special Tool List* in this section.
4. Remove spark plug wire from spark plug terminal.
5. See Figure 23 . Install free end of spark plug wire onto inline tester prong. Install tester alligator clip onto good engine ground.

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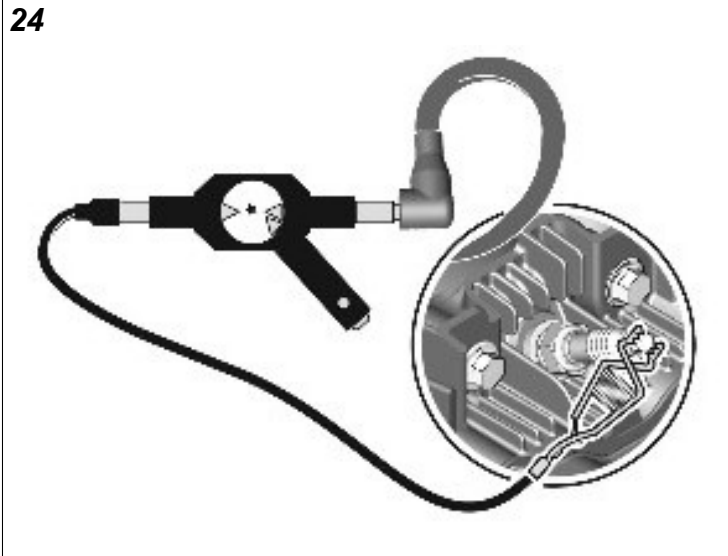


6. If equipped, move throttle control lever to FAST.
7. Activate the starter motor allowing the engine to crank. Observe the spark tester window. If a spark is observed jumping the tester gap, the ignition system is functioning.
8. If spark is not present, move to step 15.

Engine Runs But Misses

9. Obtain an Ignition Tester.
10. Remove spark plug wire from spark plug terminal.

- See Figure 24. Install free end of spark plug wire onto inline tester prong. Install tester alligator clip onto spark plug terminal.



- If equipped, move throttle control lever to FAST.
- Activate the starter motor allowing the engine to crank. Observe the spark tester window. If spark jumps the tester gap, install a **new** spark plug. If a spark is observed jumping the tester gap, install a **new** spark plug.
- If spark is not present, move to step 15.
- If spark is not present, look for:
 - Improperly operating low oil sensor system, if equipped
 - Shorted equipment or engine stop switch wire
 - Incorrect armature air gap
 - Armature failure
 - Ignition coil failure
 - Incorrect crank position sensor air gap

Check Fuel System - Carbureted Engine

- Verify that fuel tank has an ample supply of fresh, clean gasoline.
- Test fuel for alcohol content using an alcohol tester. See *SECTION 1 - SAFETY AND GENERAL INFORMATION - Fuel Recommendations* for approved fuel alcohol content.
- Verify that the fuel shutoff valve is open, if equipped, and that fuel flows freely through the fuel line. If fuel flow is slow or fails to flow, check for plugged fuel cap vent, fuel line restriction, or plugged fuel filter.
- Verify that throttle and choke controls are properly adjusted.
- If engine cranks, but will not start, remove and inspect the spark plug.

- A wet spark plug may indicate:
 - Over choking
 - Excessively rich fuel mixture
 - Water in fuel
 - Carburetor float needle valve stuck open
 - Plugged air cleaner
 - Fouled air cleaner

- A dry spark plug may indicate:
 - Leaking carburetor or intake manifold gaskets
 - Gummy or dirty carburetor, fuel filter, fuel lines, or fuel tank
 - Carburetor float needle valve stuck closed
 - Inoperative fuel pump (if equipped)
 - Inoperative fuel shut-off solenoid (if equipped)

NOTE: To determine if the fuel is getting to the combustion chamber through the carburetor, remove the spark plug and pour a small quantity of gasoline through the spark plug hole. Install the spark plug and crank the engine. If the engine fires a few times and then stops, look for the same conditions as for a dry spark plug.

Check Fuel System - Fuel-Injected Engine (EFI)

For troubleshooting steps and checks related to EFI systems, consult the applicable EFI Diagnostics and Repair Manual for your engine.

The start of any troubleshooting process must always contain a visual inspection of the system and its components. This check must always include the following:

- Verify that ECM grounds and sensor connections are clean, tight and in their proper location.
- Thoroughly check for any type of vacuum leak or restriction.
- Look for air leaks at the throttle body mounting and intake manifold sealing surfaces.
- Inspect ignition wires for cracks, hardness, improper routing and carbon tracking.
- Inspect wires for kinks, cuts, burns, abraded insulation, and other damage.
- Look for moisture in primary or secondary ignition circuit connections.
- Look for salt corrosion on electrical connections and exposed throttle body linkages.

Check electrical connectors for the following:

- Poor mating of connector halves, or a terminal not fully seated in the connector body (backed out or loose).
- Improperly formed or damaged terminals and/or connectors.
- Improper contact tension of connector pin and socket terminals in the problem circuit.
- Poor terminal to wire connection (both core and insulation crimps).

1. Visually inspect the fuel system, its components, wiring harness and connectors.
2. Perform On-Board Diagnostic (OBD) system check. *Refer to applicable EFI Diagnostic Manual.*
3. Follow the directions of the EFI troubleshooting diagnostics tables within the applicable EFI Diagnostic Manual.

Check Fuel System Pressure - EFI and EFI-ETC

The fuel rail is under high pressure. To connect the necessary fuel pressure test adaptor and gauge, it is necessary to first relieve system pressure. You must follow all steps in order to prevent an uncontrolled discharge or spray of fuel.

1. Turn Ignition OFF.
2. Loosen fuel filler cap to relieve fuel tank pressure. Tighten filler cap after loosening.
3. Remove access cover. See *SECTION 4 - REMOVE EXTERNAL ASSEMBLIES - Engine Covers.*
4. Remove air cleaner assembly. See *SECTION 4 - REMOVE EXTERNAL ASSEMBLIES - Air Cleaner Assembly.*
5. Pull out grey secondary lock and press to disconnect fuel pump module connector.
6. Turn Ignition ON, Engine ON.
7. Start and run engine until it stalls. If it does not start, crank engine a few times to relieve fuel system pressure.
8. Obtain the following tools:
 - Briggs & Stratton Fuel Pressure Gauge, see *Special Tools List* in this section.
 - Briggs & Stratton BIG BLOCK Fuel Pressure Test Adapter, see *Special Tools List* in this section.
9. Squeeze two tabs on quick disconnect fitting to release fuel rail from fuel outlet port of fuel pump module.

NOTE: Wrap shop towel around fitting to catch any fuel leakage.
10. Install fuel pressure test adapter between fuel rail and fuel pump module.
11. Remove protective cap from Schrader valve on fuel pressure test adapter and install fuel pressure gauge.
12. Connect fuel pump module connector. Push in grey secondary lock to secure.
13. Turn Ignition ON to pressurize fuel system.
14. Note the reading of the fuel pressure gauge. Fuel pressure should remain steady at **38-43 psi** (262-296 kPa).
15. Turn Ignition OFF.
16. Position the clear bleed tube in an approved container and press the pressure relief button on the gauge assembly to relieve fuel system pressure. Fully depress and hold the pressure relief button until pointer on the dial face is resting on the stop pin.
17. Remove fuel pressure gauge from Schrader valve on fuel pressure test adapter.

NOTE: A small amount of gasoline may drain from the Schrader valve when the gauge is removed. Wrap a shop towel around the valve fitting to catch any fuel leakage.

18. Install protective cap on Schrader valve.
19. Remove fuel pressure test adapter between fuel rail and fuel pump module.
20. Firmly push quick disconnect fitting on fuel rail onto fuel outlet port of fuel pump module. Gently tug on fitting to verify that it is properly seated and secure.
21. Turn ignition switch ON for two seconds, and then OFF for 10 seconds. Turn the ignition switch back to ON and check for fuel leaks.
22. Install air cleaner assembly. See *SECTION 8 - INSTALL EXTERNAL ASSEMBLIES - Air Cleaner Assembly.*
23. Install access cover. See *SECTION 8 - INSTALL EXTERNAL ASSEMBLIES - Engine Covers.*

Check Compression Components

Compression Test

An assessment of the engine's compression components can be made with a compression test.

1. Obtain a compression tester.
2. Remove both spark plugs.
3. Install the compression tester gauge into the the spark plug hole of the cylinder to be tested. Refer to the instructions included with the compression tester.
4. Turn the engine over using the starter motor until the pressure reading on the gauge no longer increases.
5. Record the pressure reading.
6. Repeat steps 3 - 5 for the other cylinder.

With pressure readings from both cylinders, note the difference between the two. Divide the difference in cylinder pressure by the value of the highest pressure reading. This indicates the difference in percentage form. A difference of over **25%** between the cylinders indicates a loss of compression in the cylinder with the lower pressure reading. See example below:

Engine Compression Comparison

	Engine #1	Engine #2
Cylinder #1	65 PSI	75 PSI
Cylinder #2	60 PSI	55 PSI
Difference	5 PSI	20 PSI
% Difference	7.7%	26.7 %

NOTE:The table above is meant for use as a reference example, **NOT** as a compression pressure specification.

Poor compression may indicate the following problem(s):

- Loose cylinder head bolts
- Blown head gasket
- Burned valves, burned and/or loose valve seats
- Warped valves
- Valve seized in guide
- Insufficient valve clearance
- Warped cylinder head
- Worn cylinder bore and/or piston rings
- Broken connecting rods

Cylinder Leakdown Test

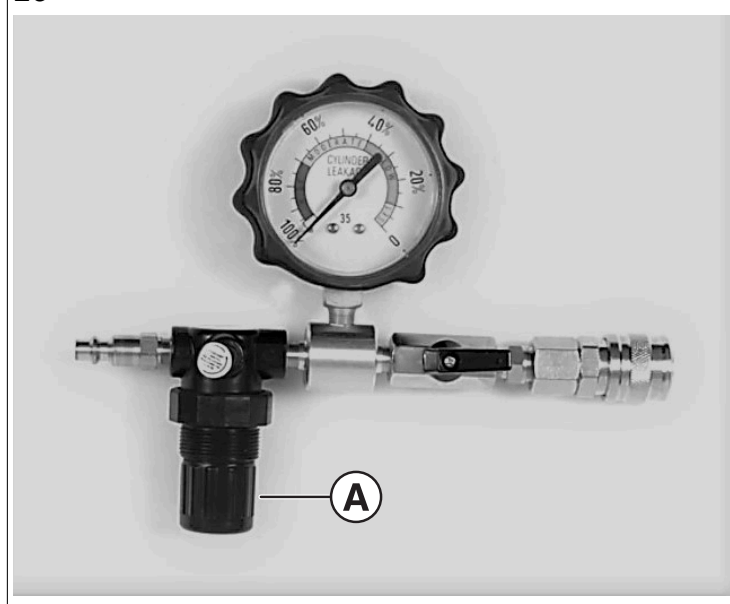
A cylinder leakdown test is used to check the sealing capabilities of each cylinder. Follow the instructions for the leakdown tester you are using for proper setup steps and testing procedures.

1. Obtain engine leakdown tester. See *Special Tool List*.
2. Remove spark plug from engine.
3. Disconnect the crankcase breather tube.

4. Rotate the crankshaft in direction of operation until the piston is at Top Dead Center (TDC) of the compression stroke on the cylinder being tested.
5. Hold the crankshaft securely in place, with the piston at TDC, to minimize the chance of rotation. This can be done by holding the flywheel nut with a socket and breaker bar.
6. Connect the leakdown tester to a compressed air source with a minimum pressure of **70 psi (480 kPa)**.
7. Install the outlet hose into the spark plug hole of the cylinder being tested.
 - a. Make sure that the outlet hose o-ring is seated correctly within the spark plug hole. The o-ring is used to prevent air leaks at the spark plug hole.
8. While holding the crankshaft securely in place, pull the leakdown tester adjustment knob **OUT (A, Figure 25)**. Slowly turn the regulator adjustment knob **CLOCKWISE** until the tester needle on the gauge is on the set point. Push the regulator adjustment knob **IN**.

NOTE: Any air leaks at the connections or fittings of the tester will affect the accuracy of the test.

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9. Open the tester valve slowly and note the reading on the gauge. A drop in pressure, as read on the leakdown tester gauge, indicates the amount leakage of the compression components being tested. The change, when expressed as a percentage, offers a good indication of the condition of the cylinder being tested. **0-10%** leakage indicates that the cylinder is good. **10-30%** leakage indicates that there may be a problem. **30-100%** leakage indicates that repairs are required.
10. Repeat steps 2 - 9 to test the other cylinder.

The sound of air flow:

- between the cylinder and cylinder head indicates the cylinder head gasket is leaking.

- from the carburetor indicates air is leaking past the intake valve and valve seat.
- from the exhaust system indicates air is leaking past the exhaust valve and valve seat.
- from the breather tube or oil fill dipstick tube indicates air is leaking past the piston rings.

Causes of poor compression and cylinder leakage:

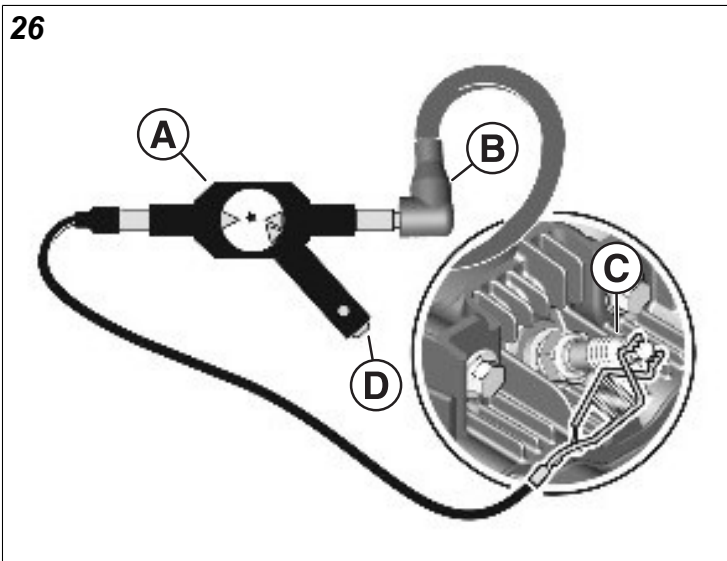
- Loose cylinder head bolts
- Damaged cylinder head gasket
- Burned valves, burned valve seats, and/or loose valve seats
- Insufficient tappet clearance
- Warped cylinder head
- Warped valve stems stem seized in guide
- Valve
- Worn cylinder bore and/or piston rings
- Broken connecting rod

Cylinder Balance Test

If the engine starts hard, runs rough, misses or lacks power, perform a cylinder balance test. This test will assist in determining whether both cylinders are operating correctly.

A cylinder balance test will also detect a cylinder that is not functioning. Grounding the spark plug of a cylinder that is not functioning will result in no RPM loss. Grounding the spark plug of the other cylinder, which is functioning, will cause the engine to stop.

1. Obtain a tachometer and 2 ignition testers. See *Special Tool List*.
2. Attach the ignition tester (A, Figure 26) between the spark plug wire (B) and spark plug (C). Repeat on both cylinders.



3. Start the engine and run at top no-load speed.
 - a. Note the spark at the ignition tester.

If the spark is equal at both ignition testers, the problem is not ignition related. A spark miss will be readily apparent. Repair and retest.
4. Connect the tachometer to the engine. See the tachometer instructions for proper placement and setup steps.
5. Note the engine RPM.
6. Ground one cylinder by contacting the ignition tester resistor (D) to a good ground on the engine.
 - a. Note any RPM loss.
7. Repeat step 6 and 6a for the other cylinder.

If the difference between the 2 cylinders does **not exceed 75 RPM**, the amount of work the 2 cylinders are doing is considered equal.

An RPM loss **greater than 75 RPM** indicates that the cylinder with the lower RPM loss is the weaker of the 2 cylinders. See example:

Engine RPM - Both Cylinders = **3400 RPM**

Engine RPM - Cylinder #1 Grounded = **3300 RPM**

Engine RPM - Cylinder #2 Grounded = **3100 RPM**

Conclusion: Cylinder #1 is the weaker cylinder.

Problems Affecting 1 Cylinder:

NOTE: A 2-cylinder engine will run on 1 cylinder as long as the power required for the application does not exceed the power produced by one cylinder.

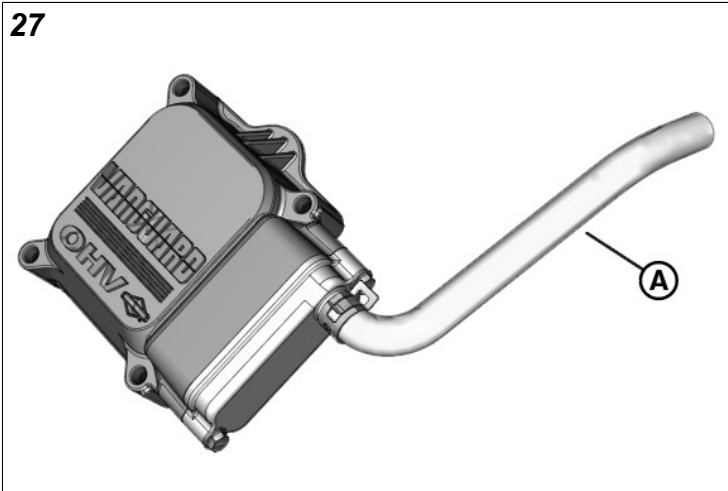
1. Spark plug - fouled, broken or worn. A fouled spark plug may indicate a fuel system problem.
2. Spark plug wire
3. Head gasket
4. Intake manifold - a leak at either end of the intake manifold will affect only 1 cylinder.
5. Valves
6. Piston rings
7. Pistons
8. Cylinder

Problems Affecting Both Cylinders:

1. Fuel system
2. Ignition timing
3. Crankcase vacuum
4. Intake loose or disconnected

Check Crankcase Breather Engine Does Not Start

1. Gently blow air into breather hose (A, Figure 27) to verify that there is no air flow through valve.



2. Apply vacuum or draw air out through breather hose to verify that air flows freely through valve.
3. If air flow has no resistance when blowing or is restricted under vacuum, the crankcase breather is faulty. See *SECTION 7 – ASSEMBLE ENGINE, TOP END ASSEMBLY, Crankcase Breather*, for replacement instructions.

Troubleshooting Guide - Gasoline Fueled Engines

The troubleshooting guide that follows is designed to outline common problems, potential causes, and repair action related to gasoline-fueled engines. This guide is applicable to both carbureted and fuel-injected engine, with the differences noted within the chart.

Gasoline-Fueled Engine Troubleshooting Chart

Gasoline-Fueled Engine Troubleshooting Chart		
Problem	Potential Cause	Action
Engine is hard to start or fails to start	No fuel in tank	Fill tank with recommended fuel
	Battery in poor condition or discharged	Check for loose or corroded terminals, broken wires, confirm that battery voltage is between 12.2 and 13.5 volts
	Perform On-Board Diagnostics (OBD) test (EFI engines)	See applicable EFI Diagnostic and Repair manual for your engine
	Fuel shutoff valve closed or anti-afterfire solenoid closed (carbureted engines)	Open shutoff valve or test anti-afterfire solenoid for proper operation
	Low fuel pressure (EFI engines)	Verify that fuel pressure is between 38 - 41 PSI (262 - 296 kPa). See applicable EFI Diagnostic and Repair manual for your engine
	MAP sensor circuit intermittent opens or shorts to ground	See applicable EFI Diagnostic and Repair manual for your engine
	Throttle Position Sensor (TPS) faulty or throttle linkage to TPS sticking, binding or worn (EFI engines)	See applicable EFI Diagnostic and Repair manual for your engine
	Intake Air Temperature sensor faulty (EFI engines)	See applicable EFI Diagnostic and Repair manual for your engine
	Engine Control Module (ECM) failure to power up	See applicable EFI Diagnostic and Repair manual for your engine
	Fuel line plugged or kinked	Clean or replace fuel line
	Fuel tank suction screen or fuel filter plugged	Clean screen or replace fuel filter
	Water in fuel tank	Drain and clean fuel tank; refill with recommended fuel
	Weak or no voltage at spark plug	See <i>Check Ignition</i>
	Spark will not jump gap	See <i>Check Ignition</i>
	Engine flooded with fuel (carbureted engine)	Open choke and close fuel tank valve or disconnect anti-afterfire solenoid; then crank engine until excess fuel is forced from exhaust
	Choke partly open (carbureted engine)	Close choke completely; if necessary, adjust choke cable
	Carburetor out of adjustment or clogged Fuel injectors clogged	Service carburetor or fuel injection system. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Carburetor</i> Replace fuel injectors
	Throttle closed	Open throttle to FAST or RUN position; check for binding throttle linkage or disconnected governor linkage
	Plugged exhaust ports	Remove muffler and clean exhaust ports
	Low or no compression	See <i>Check Compression Components</i>
	Carburetor or fuel system vent blocked	Clean vent lines and ports
	Worn or broken crankshaft/flywheel key	Check flywheel and crankshaft key for wear. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Flywheel, Crankshaft, Crankcase Cover</i>
	Faulty crankshaft position sensor	Check crankshaft position sensor. See <i>Check Crankshaft Position Sensor</i>
Faulty ignition coil	Check ignition system. See <i>Check Ignition</i>	
Improperly adjusted armature air gap	Check armature air gap and adjust to proper specification. See <i>SECTION 8 -INSTALL EXTERNAL ASSEMBLIES - Ignition Coil</i>	
Engine misfires under load	Weak or irregular spark	Check ignition system. See <i>Check Ignition</i>

Gasoline-Fueled Engine Troubleshooting Chart

Gasoline-Fueled Engine Troubleshooting Chart		
Problem	Potential Cause	Action
	Worn or fouled spark plug	Replace spark plug with new and gap to recommended specification
	Air cleaner plugged	Clean or replace air filter. See <i>SECTION 2 - MAINTENANCE - Clean/Replace Air Filter</i>
	Choke partly closed (carbureted engine)	Open choke; if necessary, adjust choke cable/control
	Fuel mixture too lean	Service carburetor or fuel injection system. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Carburetor</i> See EFI Diagnostics Manual
	Fuel system vent lines blocked or restricted	Clean or replace fuel system vent lines and port
	Fuel not reaching carburetor or fuel injectors	Clean fuel tank, clean or replace fuel lines and filters, check fuel pump operation.
	Ignition shutoff switch not in full ON position	Move or adjust shutoff switch to full ON position
	Engine running too hot	See "Engine overheats"
	Exhaust system restriction	Clean exhaust ports; remove and clean or replace muffler
	Low compression	Check engine compression components. See <i>Check Compression Components</i> <i>Check Compression Components</i>
	Weak or damaged valve springs	Replace valve springs. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Cylinder head valve springs</i>
	Engine overheats	Low engine oil
Air cooling system blocked with dirt and debris		Clean air cooling system. See <i>SECTION 2 - MAINTENANCE - Clean Air Cooling System</i>
Missing air cooling shrouds		Replace air cooling shrouds
Fuel system too lean		Service carburetor or fuel injection system. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Carburetor</i> See EFI Diagnostics Manual
Ignition system out of time		Check crankshaft/flywheel key for wear or damage. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Flywheel, Crankshaft, Crankcase Cover</i> <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Flywheel, Crankshaft, Crankcase Cover</i>
Valves out of adjustment		Adjust valves. See <i>SECTION 7 - ASSEMBLE ENGINE - Top End Assembly</i>
Engine surges, will not hold steady speed	Perform On-Board Diagnostics (OBD) test (EFI engines)	See applicable EFI Diagnostic and Repair manual for your engine
	Faulty engine wiring or ECM connector	See applicable EFI Diagnostic and Repair manual for your engine
	Fuel system vents and lines plugged or restricted	Clean or replace fuel system vent lines and ports
	Carburetor float level too low	Service carburetor. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Carburetor</i>
	Fuel tank, fuel lines, fuel filter plugged or restricted	Clean fuel tank, fuel lines, fuel filter and check fuel system components for dirt and debris
	Governor linkage binding	Clean and repair governor linkage
	Static governor adjustment not set properly	Set governor static adjustment. See <i>SECTION 2 - MAINTENANCE - Static Governor Adjustment</i>
	Throttle or throttle shaft binding	Clean and adjust throttle and throttle shaft
	Throttle or governor springs unhooked, broken, or in the wrong position	Connect or replace broken springs or return springs to correct position
	Carburetor out of adjustment or internal parts clogged with dirt and debris	Service carburetor. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Carburetor</i>
	Water or other contamination in fuel	Drain tank, fuel system, and fuel lines; replace with recommended fuel.

Gasoline-Fueled Engine Troubleshooting Chart

Gasoline-Fueled Engine Troubleshooting Chart		
Problem	Potential Cause	Action
Engine lacks power	Perform On-Board Diagnostics (OBD) test (EFI engines)	See applicable EFI Diagnostic and Repair manual for your engine
	Choke partially closed (carbureted engines)	Open choke fully
	Carburetor out of adjustment	Service carburetor. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Carburetor</i>
	Ignition improperly timed	Check crankshaft/flywheel key for wear or damage. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Flywheel, Crankshaft, Crankcase Cover</i>
	Low compression	Check engine compression components. See <i>Check Compression Components</i> Check Compression Component
	Low oil level	Check engine oil level. See <i>SECTION 2 - MAINTENANCE - Check Engine Oil</i>
	Air cleaner clogged or air intake restriction	Clean or replace air filter. See <i>SECTION 2 - MAINTENANCE - Clean/Replace Air Filter</i>
	Water or other contamination in fuel	Drain tank, fuel system, and fuel lines; replace with recommended fuel.
	Low fuel pressure (EFI engines)	Verify that fuel pressure is between 38 - 41 PSI (262 - 296 kPa). See applicable EFI Diagnostic and Repair manual for your engine
	Exhaust system restriction	Clean exhaust ports; remove and clean or replace muffler
	Engine load too great	Check equipment for damaged components, worn bearings or debris buildup
	Engine rattles, knocks or is noisy	Exhaust system leak
Engine does not run smoothly		See "Engine surges, will not hold steady speed"
Loose or worn equipment; such as mower blades, pulleys, gears, clutches, drive belts, etc.		Inspect and repair any equipment components that may be loose, worn or damaged
Worn cylinder		Inspect cylinder for wear. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Crankcase and Crankcase Cove</i>
Worn or loose connecting rod or crankshaft		Inspect and replace worn or damaged components. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Connecting Rod</i>
Bent crankshaft		Replace crankshaft. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Flywheel, Crankshaft, Crankcase Cover</i>
Loose flywheel		Tighten flywheel nut. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Flywheel, Crankshaft, Crankcase Cover</i>
Flywheel fan blades broken		Replace flywheel fan. See <i>SECTION 5 - DISASSEMBLE ENGINE - Bottom End Disassembly</i>
Ignition improperly timed		Check crankshaft/flywheel key for wear or damage. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Flywheel, Crankshaft, Crankcase Cover</i>
Loose external components		Visually inspect engine and equipment for loose components, air guides, shields and fasteners
Engine loose on equipment mounting		Tighten mounting fasteners to correct specificati

Troubleshooting Guide - Gaseous-Fueled Engines

The troubleshooting guide that follows is designed to outline common problems, potential causes, and repair action related specifically to gaseous-fueled engines.

Troubleshooting of common engine components and systems, such as the ignition system, is listed in the *Gasoline-Fueled Troubleshooting Chart*. This troubleshooting chart serves to identify potential causes of problems related directly to the liquified petroleum gas (LPG) and natural gas (NG) components of the engine.

NOTE: Always have a certified LPG/NG technician perform repairs on gaseous fuel systems.

Gaseous-Fueled Engine Troubleshooting Chart

Gaseous-Fueled Engine Troubleshooting Chart		
Problem	Potential Cause	Action
Engine is hard to start or will not start	Out of fuel	Refill the tank (LPG)
	Fuel supply shut off	Open fuel supply
	Low fuel pressure	Check the fuel pressure. Adjust fuel pressure at the regulator and verify adequate pipe size for the application
	Filter or vacuum lock-off is not opening	Check for proper operation of all fuel lock-off (safety) devices. If electronically actuated, check for dead battery or blown fuse. Replace lock-off device if it is not functioning properly.
	Vacuum leak in the vacuum lock-off device	Replace vacuum line, tighten clamps or replace vacuum lock-off if damaged.
	Faulty fuel regulator/valve	Check fuel regulator/valve operation
	Incorrect fuel mixture adjustment	Inspect fuel mixer for damage or debris. Replace if necessary
	Incorrect controller settings (standby home generator application)	Enter the correct controller settings. See generator manual for proper procedures and steps
Engine does not accelerate from low speed or high speed or run smoothly when under load	Plugged vent ports on the fuel regulator/valve	Inspect the fuel regulator/valve vent ports
	Low fuel pressure	Check the fuel pressure. Adjust fuel pressure at the regulator and verify adequate pipe size for the application
	Plugged fuel filter	Replace fuel filter
	Kinked or obstructed fuel hose	Remove the kink and/or replace the fuel hose
	Fuel tank is too small for application (LPG)	Appropriately size the fuel tank for the engine horsepower and lowest ambient temperature
	Fuel transfer switch is in the wrong position	Set the transfer switch to the correct fuel used. Either LPG or NG
	Incorrect fuel mixture adjustment	Inspect fuel mixer for damage or debris. Replace if necessary
	Air leak in the fuel line from secondary regulator to mixer/carburetor	Tighten clamps and connections or replace the line
	Holes, tears or damage in the diaphragm of the secondary regulator	Replace damaged components
	Debris and contamination on inlet needle of regulator	Clean system of debris and contamination. Add fuel filter
Frost forming on the regulator or on the fuel line - liquid (not vapor) entering the system	Wrong type of propane tank - set up for liquid withdrawal	Replace the fuel tank or change to the vapor withdrawal port
	Fuel tank is positioned incorrectly	Fuel tanks have a receptacle for a locator pin that orients the tank for a specific withdrawal. Pin may be in the wrong location or missing. Reposition tank
	Fuel tank is overfilled	Fill to labeled tank capacity only
	Fuel tank is too small, especially if the ambient temperature is low	Increase the size of the fuel tank to increase the vaporization rate of the fuel. Consult with local gas supplier
	Restriction within the fuel line	Remove restriction or replace damaged part
Gas will not stop flowing after engine is stopped	Regulator is not adjusted properly	Consult equipment service manual for proper procedures and steps

Gaseous-Fueled Engine Troubleshooting Chart

Gaseous-Fueled Engine Troubleshooting Chart		
Problem	Potential Cause	Action
	Debris and contamination on inlet needle of regulator	Clean system of debris and contamination. Add fuel filter
	Regulator not positioned vertically	Regulator may only be positioned with the outlet pointing straight up. A directional arrow is also shown on the smooth side of the regulator
Gas leak from fuel line	Loose fitting	Tighten fitting; replace if damaged
	Damaged, cracked or worn hose	Replace hose
Gas leak from regulator	Damaged diaphragm in regulator	Replace damaged components

Additional Troubleshooting Help

Your equipment may feature certain systems that can prevent the engine from operating or cause poor operation characteristics. Follow standard troubleshooting procedures to determine the cause of the problem. If the problem cannot be located on the engine, there may be an issue with the equipment.

Consult the equipment repair manual and follow the troubleshooting procedures and steps.

System Diagnosis - Alternator

The troubleshooting guide that follows is designed to outline common problems, potential causes, and repair action related to the alternator system. This guide is applicable to both carbureted and fuel-injected engines.

Alternator System Troubleshooting

Alternator System Troubleshooting		
Problem	Potential Cause	Action
Battery not charging	Engine RPM too low	Check and adjust engine speed. Check engine for excessive load.
	Inline fuse blown (if equipped)	Check fuse, replace if necessary.
	Defective battery	Test battery. See <i>Test Battery</i> .
	Loose, pinched, or corroded battery ground leads	Inspect battery ground leads. Test, clean, or replace if necessary.
	Loose, pinched, or corroded battery charge leads	Inspect battery charge leads. Test, clean, or replace if necessary.
	Open, shorted, or grounded wires between output connector and battery	Test wiring. Repair or replace if necessary.
	Defective or improperly grounded regulator-rectifier	Test regulator-rectifier and ground. Repair or replace if necessary.
	Damaged battery	Inspect and test battery. See <i>Test Battery</i> . Replace if necessary.
	Excessive current draw from accessories	Check current draw, turn off or disconnect accessories, test accessories for excessive draw.
	Low magnetic flux or damaged alternator magnets	Inspect components. Replace if necessary.
Battery overcharged	Mismatched battery to alternator output	Check equipment operator's manual for correct battery specifications.
	Damaged battery	Inspect and test battery. See <i>Test Battery</i> .
	Defective regulator	Test regulator. Replace if necessary.
Accessories or auxiliary equipment not working	Inline fuse blown	Inspect and test fuse. Replace if necessary.
	Defective auxiliary accessories or auxiliary equipment	Inspect and test equipment. Repair or replace if necessary.
	Loose or corroded wires	Inspect and test wiring. Repair or replace if necessary.
	Open, shorted or grounded wires between output connector and accessories	Inspect and test wiring. Repair or replace if necessary.
	Accessory or auxiliary equipment switch defective	Test switch. Replace if necessary.

Charging System Identification

The alternator systems installed on Briggs & Stratton Model 540000 and 610000 OHV V-Twin engines can be identified by the number of stator output wires OR by the voltage regulator style.

Alternator Type	Stator Output Wires	Alternator Output (at 3600 RPM)
Regulated 20 Amp	1 - Connector, 2 - Yellow Wires	1 - 20 DC Amps, 30 AC Volts
Regulated 20/50 Amp	2 - Connectors, 4 - Yellow Wires	3 - 50 DC Amps, 45 - 50 AC Volts

Regulator Type	Regulator Wires	Notes
20 Amp	2 - Yellow, 1 - Red	
20/50 Amp	4 - Yellow, 1 - Red	20/50 Amp regulator will have an inline fuse on the red wire and a capacitor mounted to the top regulator mounting bracket.

Testing Alternator Output

20 Amp Regulated Alternator

Output Test - 20 Amp Alternator

1. Obtain a digital multimeter. See *Special Tools List* in this section.
2. Disconnect the stator wire harness from the voltage regulator.
3. Set-up the digital multimeter by inserting the RED test lead into the volt/ohm receptacle of the meter and the BLACK test lead into the COM receptacle of the meter.
4. Select AC VOLTS on the multimeter.
5. Connect the RED and BLACK test lead probes onto the output terminals of the stator.

NOTE: Test lead probes may be attached to either terminal. Alligator style probe clips may be necessary to maintain a positive connection.

6. Start the engine.
7. With the engine running at **3600 RPM** output should be no less than **30 Volts**.

Regulator-Rectifier Test - 20 Amp

NOTE: Make sure that the regulator is securely mounted to the engine. The regulator will not function unless it is grounded to the engine. When testing the regulator for amperage output, a 12 volt battery with a minimum charge of 5 volts is required. There will be no output if battery voltage is below 5 volts.

2 tests must be performed to confirm a properly operating voltage regulator. A DC Amp test and a DC Voltage test.

1. If previously disconnected, re-connect the stator wire harness to the regulator.
2. Obtain a digital multimeter with inductive clamp. See *Special Tools List* in this section.
3. Place the inductive clamp of the multimeter over the RED regulator output wire.
4. On the multimeter, select the DC Amps position on the selector wheel.
5. Start the engine.
6. With the engine running at **3600 RPM**, the output should be **1-20 Amps**.

NOTE: Amp reading is dependent upon battery voltage and/or current draw on the system.

7. See steps 1-3 of the previous test.
8. On the multimeter, select the DC Volts position on the selector wheel.
9. Start the engine and allow to run for 15 minutes.

10. With the engine running at **3600 RPM**, the output should be between **13.9 and 14.5 VDC**.

20/50 Amp Regulated Alternator

Output Test - 20/50 Amp Alternator

1. Obtain 2 digital multimeters. See *Special Tools List* in this section.
2. Disconnect the stator wire harness from the voltage regulator.
3. Set-up the digital multimeters by inserting the RED test lead into the volt/ohm receptacle of the meter and the BLACK test lead into the COM receptacle of the meter.
4. Select AC VOLTS on the multimeters.
5. Connect the RED and BLACK test lead probes onto the output terminals of the stator.

NOTE: Test lead probes may be attached to either terminal. Alligator style probe clips may be necessary to maintain a positive connection.

6. Start the engine.
7. With the engine running at **3600 RPM** output should be **45-50 Volts** on each stator output.

Regulator-Rectifier Test - 20/50 Amp

NOTE: Make sure that the regulator is securely mounted to the engine. The regulator will not function unless it is grounded to the engine. When testing the regulator for amperage output, a 12 volt battery with a minimum charge of 5 volts is required. There will be no output if battery voltage is below 5 volts.

2 tests must be performed to confirm a properly operating voltage regulator. A DC Amp test and a DC Voltage test.

1. If previously disconnected, re-connect the stator wire harness to the regulator.
2. Obtain a digital multimeter with inductive clamp. See *Special Tools List* in this section.
3. Place the inductive clamp of the multimeter over the RED regulator output wire.
4. On the multimeter, select the DC Amps position on the selector wheel.
5. Start the engine.
6. With the engine running at **3600 RPM**, the output should be **3-50 Amps**.

NOTE: Amp reading is dependent upon battery voltage and/or current draw on the system.

7. See steps 1-3 of the previous test.
8. On the multimeter, select the DC Volts position on the selector wheel.
9. Start the engine and allow to run for 15 minutes.
10. With the engine running at **3600 RPM**, the output should be between **13.9 and 14.5 VDC**.

NOTE: On engines equipped with "battery-less" charging systems, the output should be between **12.9 and 13.9 VDC**.

Anti-Afterfire Solenoid - Carbureted Engines

The anti-afterfire solenoid, mounted to the carburetor, operates a plunger that stops the flow of fuel through the fixed main jet. This is controlled by the equipment ignition switch. With the ignition switch in the **OFF** position, the solenoid plunger closes, stopping the flow of fuel. With the switch in the **ON** and in the **START** positions, the solenoid plunger opens to allow normal fuel flow.

The solenoid is operating as normal if it **CLICKS** when the ignition switch is turned **ON** and **OFF**.

If the solenoid does not **CLICK**, a problem may exist in the equipment wiring, engine wiring, or the solenoid. Perform the following tests in the order listed below.

Solenoid Test

1. Disconnect the wire harness electrical connector and remove the anti-afterfire solenoid from the carburetor (see *SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Carburetor - Disassembly*). Wrap with a shop towel to catch any spilled fuel.
2. Connect a jumper wire from the negative terminal of the equipment 12V battery to either terminal of the solenoid connector.
3. Connect a jumper wire from the positive terminal of the equipment 12V battery to the other terminal of the solenoid connector.

The plunger should retract freely.

When the battery connection is removed, the plunger should return to the extended position.

Replace the solenoid if the plunger sticks or doesn't move.

NOTE: Test the anti-afterfire solenoid when at room temperature and when the engine is at operating temperature. Excessive heat may cause failure.

Equipment Wiring Test

1. Turn the key switch to **OFF**.
2. Disconnect the equipment wiring harness from the engine wiring harness.
3. Obtain a digital multimeter.
4. Attach the RED meter test lead into the equipment wiring harness connector (side opposite of raised rib on harness connector).
5. Attach the BLACK meter test lead to a good ground.

6. Turn the key switch to **ON**. The multimeter should display battery voltage.

If the meter **DOES NOT** display battery voltage, the problem exists within the equipment wiring harness. Consult equipment repair manual for testing procedures.

If the meter **DOES** display battery voltage, test the engine wiring harness. See *Testing Engine Wiring Harness* in this section.

Testing the Battery

Battery Voltage Test

1. Verify that the correct battery for the engine and application is installed. Consult the equipment owner's manual for proper battery specification.
2. Obtain a digital multimeter.
3. Connect the RED test lead to the volt/ohm receptacle of the meter and the BLACK test lead to the COM receptacle of the meter.
4. Select DC VOLTS on the multimeter.
5. Attach the RED meter test lead probe to the POSITIVE (+) battery terminal.
6. Attach the BLACK meter test lead probe to the NEGATIVE (-) battery terminal.
7. Observe the multimeter display. Record results. The multimeter display should display **12 volts** or ABOVE on a good battery. If the battery voltage is between 10-12 volts, fully charge the battery prior to continuing with troubleshooting. If the battery voltage is less than 10 volts, replace the battery prior to continuing troubleshooting.

NOTE: If testing battery voltage on a gaseous-fueled standby generator engine, the observed battery voltage must read **13 volts** or higher. Standby home generators are equipped with a battery charge maintenance circuit, or "trickle-charger" that maintains battery voltage. If battery voltage of LESS THAN 13 volts is observed, check the battery maintenance charger circuit. See *Air-Cooled Standby Generator Electrical Troubleshooting and Repair Manual* for troubleshooting and testing procedures.

8. Proceed to Battery Load Test.

Battery Load Test

To perform a battery load test WITHOUT the use of a battery load test tool, proceed as follows. If using a battery load test tool, see tool instructions for proper testing procedures.

1. Obtain a digital multimeter.
2. Connect the RED test lead to the volt/ohm receptacle of the meter and the BLACK test lead to the COM receptacle of the meter.
3. Select DC VOLTS on the multimeter.

4. Connect the RED test lead probe to the POSITIVE terminal of the battery, and the BLACK test lead probe to the NEGATIVE terminal of the battery.
5. Disconnect BOTH ignition wires from the spark plugs and secure to avoid arcing.

NOTE: On gaseous-fueled standby generator engines, turn fuel supply OFF.

6. Crank the engine for 15 seconds and monitor the voltage drop on the multimeter display.
If the observed battery voltage reading remains ABOVE **9.6 volts** the battery is OK. If the observed battery voltage reading is EQUAL TO OR BELOW **9.6 volts**, replace the battery with new before continuing.

Test Engine Wiring Harness

Test Engine Wiring

If equipped with an EFI or EFI-ETC engine, consult the appropriate *EFI and EFI-ETC Service & Diagnostics* manual for engine wire harness testing, pin-outs, and wiring schematics.

If equipped with a carbureted or gaseous-fueled engine, the wiring harness consists of a ground wire, a wire with a diode for each armature, a wire for the anti-afterfire solenoid, and a wire for the oil pressure sensor. Depending on your engine configuration and equipment, additional wiring may be present. For testing, service and troubleshooting of the equipment wiring harness, see the equipment service and repair manual.

Testing Wire Harness Diodes

1. Obtain a digital multimeter with test leads. See *Special Tools List* in this section.
2. Insert the RED test lead into the volt/ohm receptacle on the meter.
3. Insert the BLACK test lead into the COM receptacle on the meter.
4. Select the DIODE TEST position on the meter.
5. Connect the RED test lead clip to the BLACK wire pin in the engine harness connector (usually pin 5 on a 6-pin connector).
6. Connect the BLACK test lead clip to the armature electrical connector.
 - a. Observe the multimeter display, if the reading is between **0.6 and 0.7 volts**, then the diode is healthy and working correctly.
7. Reverse the meter test lead clips so that the RED test lead clip is attached to the armature connector and the BLACK test lead clip is attached to the engine harness connector.

- a. Observe the multimeter display. The meter should read **OL** if the diode is healthy and working correctly.

If the meter shows values different than the above values, the diode is defective. The diode can be either open or short.

An OPEN diode means that current cannot flow in either direction. The meter will read **OL** in both testing positions.

A SHORTED diode means that current flows in both directions and the voltage drop across the diode will be between **0 and 0.4 volts**.

8. Test the other armature wiring and diode. Repeat steps 1 - 7.

Test Engine Wire Harness Continuity

A continuity test is a simple but effective test to determine whether the component wire(s) are damaged or broken. This condition would prevent a specific component from operating correctly, or at all.

1. Obtain a digital multimeter. See *Special Tools List* in this section.
2. Connect the RED test lead into the volt/ohm receptacle on the meter.
3. Connect the BLACK test lead into the COM receptacle on the meter.
4. Set the multimeter to read CONTINUITY. Usually marked with the Ohm symbol. Set the range to the lowest value.
5. Select the specific component wire to be tested. Disconnect the wire and connector from the component.
6. Attach the RED test lead clip to the component wire electrical connector.
7. Attach the BLACK test lead clip to the terminating end of the component wire, usually within a wiring harness connector or main engine harness connector.
8. Allow the meter reading to stabilize, then observe the meter display.
 - a. A meter displaying **0 Ohms** indicates perfect continuity.
 - b. A meter displaying **less than 1 Ohm** has good continuity.
 - c. A meter displaying **1 or higher** may be an indication high resistance. Check the electrical terminals being tested for dirt or corrosion.
 - d. A meter displaying **OL** indicates that NO continuity exists. Check the wire for breaks, replace as necessary.

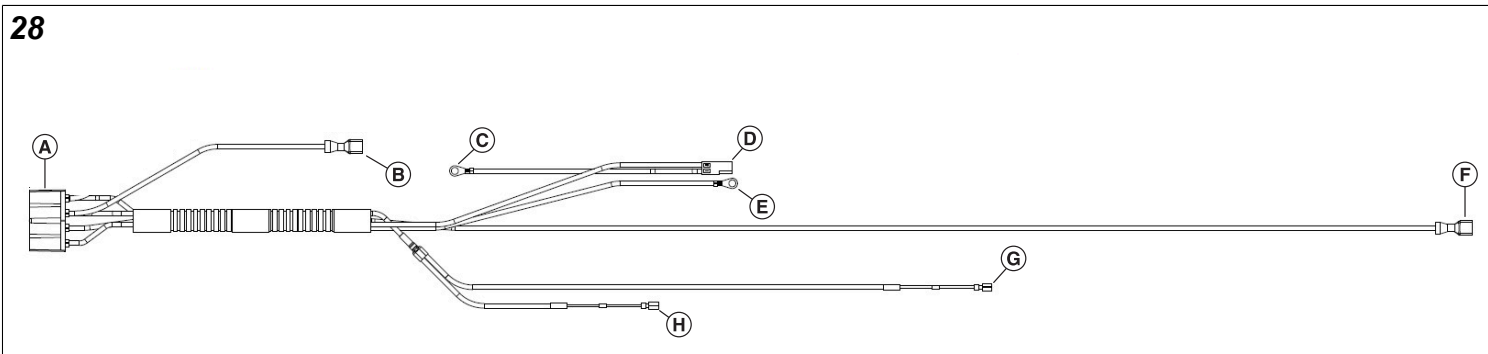
Engine Wiring Harness Diagram

EFI and EFI-ETC Engine

Refer to the EFI and EFI-ETC Diagnostic Manual that corresponds to your engine for pin-outs and diagnostic troubleshooting of the engine wiring harness.

Carbureted and Gaseous Engines

Your engine model may be fitted with additional equipment or lack components which may alter the appearance of the wire harness. Figure 28 shows a typical wire harness for carburetor equipped engines. Your engine may vary.



Carbureted Engine Wire Harness

Harness Connector	Component	Wire Color
Connector A	Engine harness to equipment harness connector	Black connector
Connector B	Starter Solenoid	Yellow Wire
Connector C	Ground Wire	Brown Wire
Connector D	Anti-Afterfire Solenoid or Fuel Cut-Off	Gray Wire and Brown Wire
Connector E	Ground Wire	Brown Wire
Connector F	Oil Pressure Switch	Green Wire
Connector G	Ignition Armature	Black Wire
Connector H	Ignition Armature	Black Wire

Carbureted and Gaseous Engine Wire Harness Connector Pin-Out

The style and configuration of the engine-to-equipment harness connector is determined by your engine's model, trim, and type. The table that follows can be used as a general guide to aid in the diagnostics and pin-out of the engine harness connector. Component wire colors are generally consistent across all engine models, trims, and types, but care must be taken to independently confirm that the connector wire matches the component wire.

Carbureted Engine Wire Harness Connector Pin-Out Identification

Component	Wire Color
Ground Wire	Brown
Ignition Wire	Black
Oil Pressure Switch	Green
Starter Solenoid	Yellow
Fuel Solenoid	Gray

Oil Pressure

Test Oil Pressure Switch

2 types of oil pressure switches may be used on your engine, depending on the model, trim and type. The first type is a **Normally-closed** oil pressure switch. With the engine OFF, the contacts within the switch are CLOSED, completing a circuit. When oil pressure is built up as the engine starts, the switch opens and the ground contact is interrupted. Normally-closed oil pressure switches are used to activate items such as an alarm or warning light if the oil pressure drops to a predetermined PSI level.

The second type is a **Normally-open** oil pressure switch. With the engine OFF, the contacts within the switch are OPEN, interrupting the circuit. When oil pressure is built up as the engine starts, the switch closes the ground contact, completing the circuit. Normally-open oil pressure switches may be used to activate items such as an hour meter when the oil pressure reaches a predetermined PSI level.

It is important to determine the type AND specification of the oil pressure switch on your engine BEFORE testing. Review the *Illustrated Parts List* to determine the correct part specification.

1. Obtain a digital multimeter. Set meter to test for continuity. See *Special Tool List*.
2. Remove oil pressure switch from engine. See *SECTION 4 - REMOVE EXTERNAL ASSEMBLIES - Oil Pressure Switch*.
3. Connect on tester lead to the oil pressure switch terminal and the other lead to the metal body of the switch. If equipped with a **Normally-closed** oil pressure switch, the tester should indicate **CONTINUITY** when no pressure is applied to the switch. If equipped with a **Normally-open** oil pressure switch, the tester should indicate **OPEN** when no pressure is applied to the switch. Replace the switch if the test results are not to specification.
4. If the oil pressure switch is within specification but the warning light remains ON, proceed to oil pressure test.

Test Oil Pressure

The engine oil level must be between the LOW and FULL mark on the dipstick. If the oil level is low, check for leaks and add oil to FULL mark.

1. Obtain oil pressure gauge.
2. Remove the oil pressure switch or the 1/8" NPTF plug on the engine crankcase.
3. Install the oil pressure gauge. See gauge instructions for proper procedures and steps.

4. Start the engine. Allow the engine to run for approximately **5 minutes**.
5. Check the oil pressure at **3000 RPM**. Oil pressure should read between **10-50 PSI (0.7-3.5 Bar)**.

Oil Pressure Troubleshooting Guide	
Low Oil Pressure	Engine RPM too low
	Wrong viscosity or diluted oil
	Low oil level
	Broken pressure relief spring
	Missing pressure relief plunger
	Worn bearings
High Oil Pressure	Damaged or defective oil pump
	Wrong viscosity oil
	Plugged oil passages
	Stuck pressure relief plunger

Starter Motor

Conditions Affecting Starter Motor Performance

1. Bound or seized starter motor bearings.
2. A shorted, open or grounded armature.
 - a. Shorted armature (wire insulation worn and wires touching one another) will be indicated by **LOW** or **NO RPM**.
 - b. Open armature (wire broken) will be indicated by **LOW** or **NO RPM** and excessive current draw.
 - c. Grounded armature (wire insulation worn and wire touching armature lamination or shaft) will be indicated by excessive current draw and **NO RPM**.
3. A defective starter motor switch.
4. Broken, damaged or weak magnets.
5. Dirty or binding starter drive.
6. Defective or damaged wires, cables and terminal connections.
 - a. High resistance on either the positive or negative side of the starter motor can reduce the current to the starter motor. This will cause **LOW** cranking speeds.
 - b. High resistance on the the starter motor solenoid control circuit reduces the current to the solenoid switch. This can prevent the starter from operating.
 - c. Excessive voltage loss, from defective or damaged wires, cables and connections will affect starter motor performance.

Troubleshooting - Starter Motor

If a starting problem is encountered, check the engine to eliminate it as the cause of the problem. Check the engine for freedom of rotation by removing the spark plugs and turning the crankshaft over slowly by hand.

Starter Motor Troubleshooting

Starter Motor Troubleshooting Guide		
Problem	Potential Cause	Action
Engine Cranks Slowly	Additional load affecting performance	Reduce load on engine and retest
	Faulty electrical connection (battery circuit)	Test electrical connections and wiring
	Discharged battery (see also the alternator as a possible cause of discharged battery)	Test battery and test alternator and regulator. See <i>Testing the Battery</i> and <i>Testing Alternator Output</i>
	Dirty or worn starter motor commutator, bearing, weak magnets, etc.	Replace starter motor
	Worn brushes or weak brush spring	Replace starter motor
	Wrong oil viscosity	Replace engine oil with recommended specification
	Battery leads too long or wire too small	Test and replace, if necessary, battery leads
	Battery too small	Replace battery with recommended specification
Engine Will Not Crank	Faulty safety interlocks	Test safety interlocks. Replace as necessary
	Discharged or defective battery	Test battery. See <i>Testing the Battery</i> . Replace as necessary
	Faulty electrical connections	Test electrical connections and wiring. Clean, repair, or replace as necessary
	Faulty starter motor switch (open circuit)	Test switch. Replace as necessary
	Open circuit in starter motor	Replace starter motor
	Brushes sticking, etc.	Replace starter motor
	Faulty solenoid	Replace solenoid. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Starter Motor Solenoid</i>
Starter Motor Spins But Does Not Crank Engine	Sticking pinion gear due to dirt	Clean pinion gear
	Damaged pinion or ring gear	Replace starter motor or flywheel
	Starter clutch slipping	Replace starter motor
	Reverse rotation due to incorrect motor polarity – all motors rotate counterclockwise viewed from pinion gear	Replace starter motor
Starter Motor Spins But Does Not Stop	Defective starter switch	Test switch. Replace as necessary
	Defective starter solenoid	Replace solenoid. See <i>SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Starter Motor Solenoid</i>

Starter Motor Solenoid Continuity Test

The starter solenoid is a normally open, electrically activated switch. When the key switch is turned to the START position, the switch closes, allowing battery current to flow to the starter motor and crank the engine.

The solenoid may be tested while mounted on engine.

1. Obtain a digital multimeter and a jumper test lead.
2. Remove POSITIVE battery cable from battery. Remove battery cable from stud terminal on solenoid.
3. Disconnect YELLOW wire from the CONTROL CIRCUIT terminal (C, Figure 29) on the solenoid.
4. Key switch must be in OFF position.
5. Insert RED multimeter test lead into the volt and ohm receptacle.
6. Insert BLACK test lead into COM receptacle in meter.

7. Rotate meter selector to Diode Test position.
8. Attach one meter test lead to each stud terminal on solenoid.
9. Attach one end of jumper lead to POSITIVE terminal on battery.
10. Touch jumper wire to the CONTROL CIRCUIT terminal on solenoid.

An audible "CLICK" should be heard as the solenoid switch closes. The multimeter should indicate continuity. If the starter motor fails to crank the engine, proceed to *Starter Motor Solenoid Voltage Test* in this section.

If the solenoid does NOT "click" or the multimeter indicates NO continuity, replace starter solenoid. See *SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Starter Motor Solenoid*.

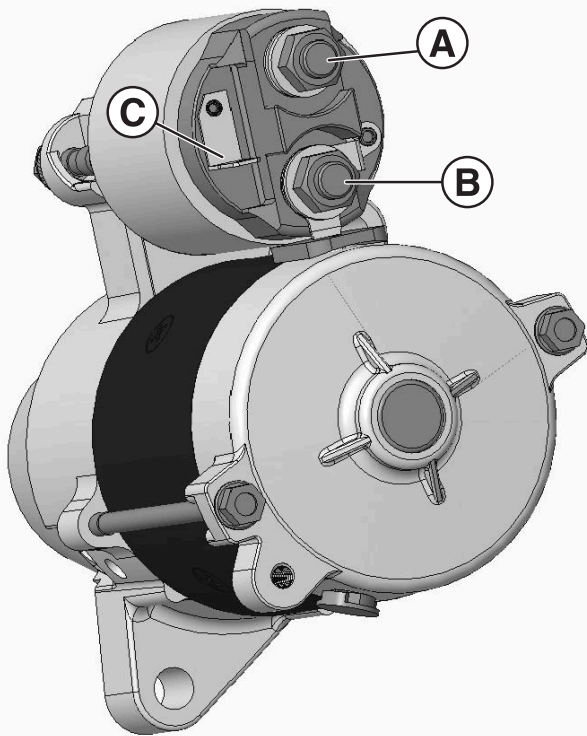
Starter Motor Solenoid Voltage Test

Prior to conducting this test, make sure the battery is fully charged and in good condition, see *Testing the Battery*.

This is a 2-part test. Part 1 (steps 1-6) tests the starter motor solenoid input or feed voltage and part 2 (steps 7- 12) tests the solenoid output voltage. BOTH tests must be done for accurate starter motor diagnostics.

1. Obtain a digital multimeter.
2. Connect the RED test lead to the volt/ohm receptacle of the meter and the BLACK test lead to the COM receptacle of the meter.
3. Select DC VOLTS on the multimeter.
4. Connect the RED test lead probe to the INPUT/ FEED terminal (A, Figure 29) of the starter motor solenoid.

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5. Connect the BLACK test lead probe to a good GROUND.
6. Observe the multimeter display and record result.

The multimeter display should indicate battery voltage, confirm by testing battery voltage, see *Battery Voltage Test*. If the multimeter DOES NOT display battery voltage, check the cables, wiring and electrical connections between the battery POSITIVE (+) terminal and the solenoid INPUT/FEED terminal (A).

7. For testing the solenoid output voltage, proceed as follows:
8. Disconnect BOTH ignition wires from the spark plugs.

NOTE: On gaseous-fueled standby generator engines, turn fuel supply OFF.

9. Connect the RED multimeter test lead probe to the OUTPUT terminal (B) of the starter motor solenoid.
10. Connect the BLACK multimeter test lead probe to a good GROUND.
11. Turn the key switch to START and observe the multimeter display.
12. The multimeter display should indicate battery voltage.

If the multimeter display DOES NOT indicate battery voltage, the solenoid is faulty. Replace starter motor solenoid, see SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - Starter Motor Solenoid.

If the multimeter display indicates **0 volts**, conduct a *Starter Motor Solenoid Continuity Test*. See test in this section.

If battery voltage is present, but the starter motor DOES NOT spin, the starter motor may be faulty. Conduct a *Starter Motor Solenoid Load and Current Draw Test* prior to replacing the starter motor. See SECTION 4 - REMOVE EXTERNAL ASSEMBLIES - Starter Motor for replacement procedure.

Starter Motor Solenoid Load and Current Draw Test

Prior to conducting a solenoid load test, you must conduct a battery load test, see *Battery Load Test* in this section. The results of the battery load test are necessary for comparison to the solenoid load test.

On standby home generator applications, disconnect the battery maintenance/trickle charger circuit prior to conducting the solenoid load and current draw test. The additional voltage and current supplied by the charging circuit can alter the test results.

1. Obtain a digital multimeter.
2. Disconnect BOTH ignition wires from the spark plugs.

NOTE: On gaseous-fueled standby generator engines, turn fuel supply OFF.

3. Connect the RED test lead to the volt/ohm receptacle of the meter and the BLACK test lead to the COM receptacle of the meter.
4. Select DC VOLTS on the multimeter.
5. Connect the RED test lead probe to the POSITIVE (+) or INPUT/FEED solenoid terminal.
6. Connect the BLACK test lead probe to a good GROUND.

7. Crank the engine for 15 seconds and observe the multimeter display. Record results.
The observed voltage reading should match the observed reading from the battery load test. If the voltage drop is HIGHER than observed on the battery load test, check cables, wiring and connectors between the solenoid and the battery.
8. Select AMPS on the multimeter, or if equipped, install the multimeter inductive clamp on the POSITIVE (+) battery cable.
9. Crank the engine for 15 seconds and observe the multimeter display. Record results.

The observed current draw (amps) should not exceed **190 amps**. See *SPECIFICATIONS - Engine Parameter Specifications*. If the current draw is HIGHER than specified, replace the starter motor. See *SECTION 4 - REMOVE EXTERNAL ASSEMBLIES - Starter Motor*.

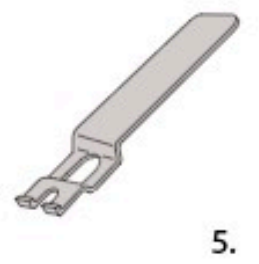
SPECIAL TOOLS

Special Tools List

1. Piston Ring Compressor (Part No. 19070)
2. Flywheel Puller (Part No. 19203)
3. Valve Lapping Tool (Part No. 19258)
4. Piston Ring Expander (Part No. 19340)
5. Valve Spring Compressor (Part No. 19347)
6. Valve Guide Remover Driver (Part No. 19367)
7. Ignition Tester (Part No. 84003327)
8. Torque Wrench (Part No. 19393)
9. Strap Wrench (Part No. 19433)
10. Valve Adjustment Set (Part No. 19465)
11. Tang Adjusting Tool (Part No. 19480)
12. Dial Bore Gauge (Part No. 19487)
13. Leakdown Tester (Part No. 19545)
14. Master Seat Cutter Kit (Part No. 19547)
15. Digital Tachometer/Hour Meter (Part No. 19598)
16. Digital Multimeter (Part No. 19602)
17. Fuel Hose Remover (Part No. 19620)
18. Fuel Pressure Adaptor (Part No. 19624)
19. Fuel Pressure Gauge (Part No. 19627)
20. Silicone Sealant (Part No. 100106)
21. Armature Air Gap Gauge (Part No. CE5121)

Special Tools Image Chart

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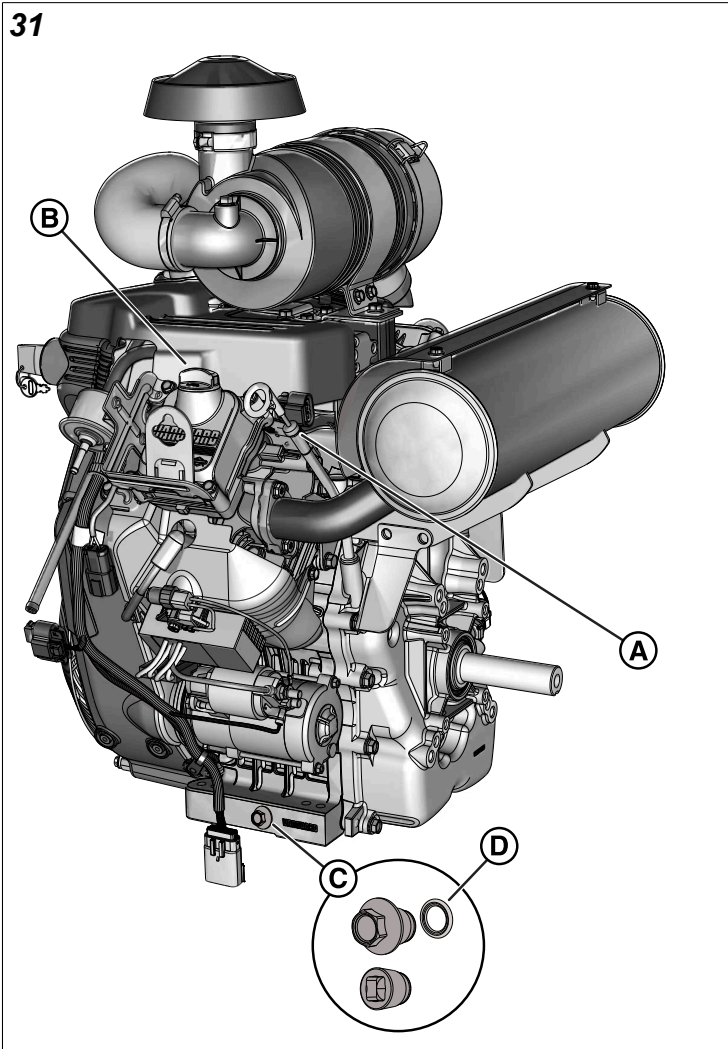
REMOVE EXTERNAL ASSEMBLIES

Preliminary Instructions

Prior to starting any repair or maintenance operation. Make sure you are familiar with ALL safety warnings and procedures as outlined in *SECTION 1 - SAFETY AND GENERAL INFORMATION - Safety Information*.

ALWAYS wear safety glasses and gloves while performing any maintenance and repair operation.

1. Remove spark plug wires from spark plug terminals. Secure spark plug wires to prevent unintentional contact with spark plug terminals.
2. Place engine on a flat, level surface.
3. Remove dipstick (A, Figure 31) and wipe with a clean, lint free cloth.



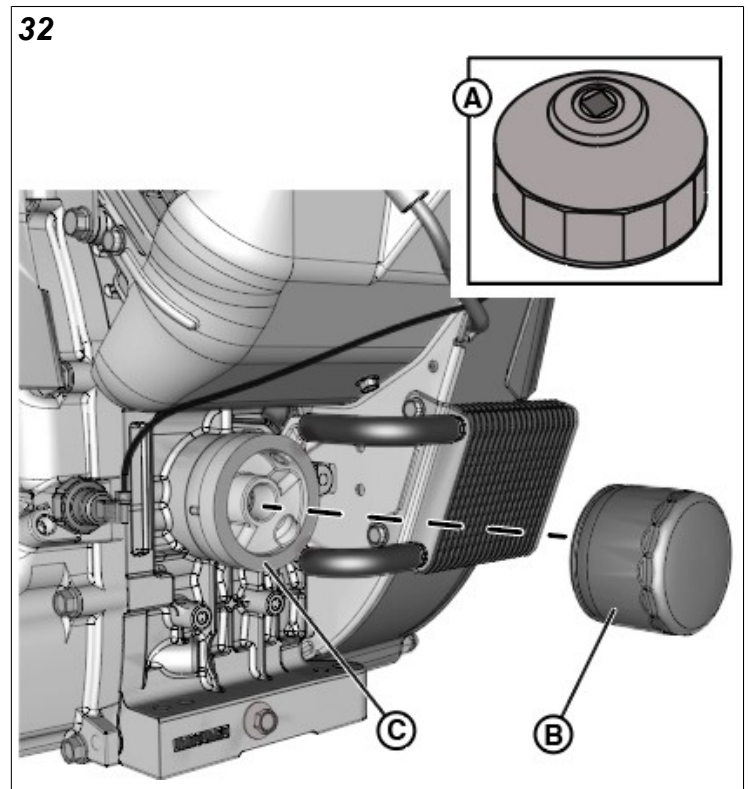
4. Remove oil fill cap (B) from valve cover.
5. Remove oil drain plugs (C) at base of engine and drain oil into an approved container. Remove and discard drain plug O-rings (D), if equipped.
6. Dispose of used oil and oil filter at a proper waste disposal or recycling center.

Relieve Fuel System Pressure - EFI and EFI-ETC

1. Turn Ignition OFF.
2. Loosen fuel filler cap to relieve fuel tank pressure. Tighten filler cap after loosening.
3. Remove access cover. See *Engine Covers* in this section.
4. Remove air cleaner assembly. See *Air Cleaner Assembly* in this section.
5. Pull out gray secondary lock and press to disconnect fuel pump module connector.
6. Turn Ignition ON, Engine ON.
7. Start and run engine until it stalls. If it does not start, crank engine a few times to relieve fuel system pressure.

Oil Filter

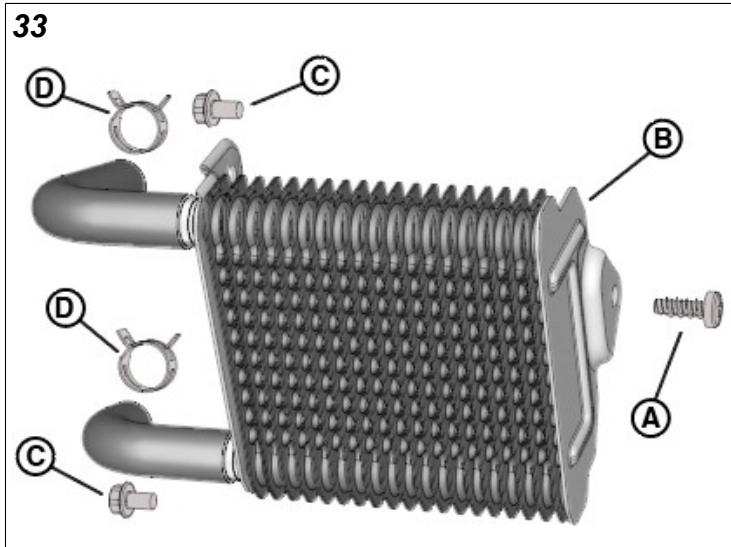
1. Obtain a 76mm-14 Flute end cap style oil filter wrench (A, Figure 32).



2. With the oil filter wrench attached to a ratchet and extension bar, turn oil filter (B) in a counterclockwise direction until loose, and then remove by hand. Do not use air tools.
3. Clean the oil filter mount flange (C) of any old gasket material.
4. Discard old oil filter and oil in the appropriate receptacle.

Oil Cooler

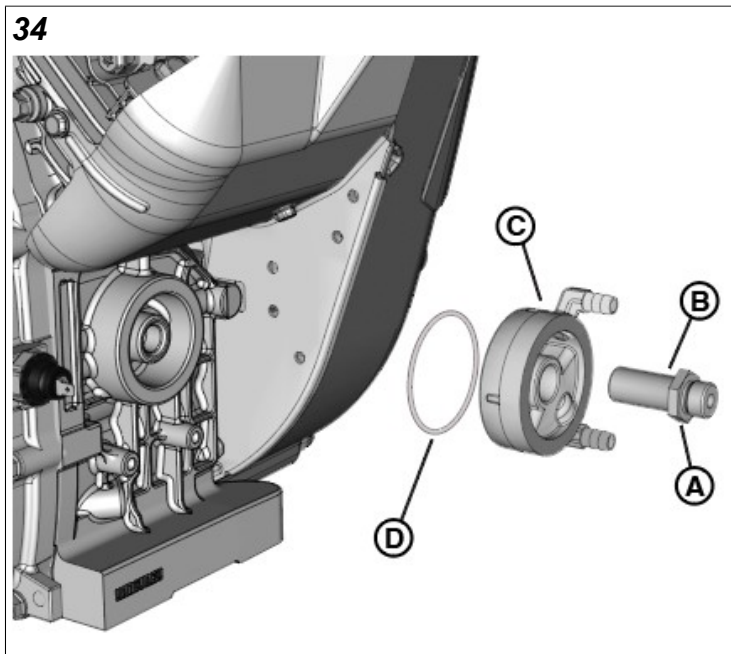
1. Remove the fastener (A, Figure 33) to release oil cooler top bracket (B) from blower housing.



2. Remove the 2 fasteners (C) to release bottom bracket from back plate.
3. Squeeze tangs and move hose clamps (D) away from diverter oil inlet and outlet fittings. Remove hoses from diverter. Use the Fuel Line Removal Tool for best results. See SECTION 3 - TROUBLESHOOTING - Special Tool List.
4. Drain any remaining engine oil within the oil cooler to an appropriate disposal container.

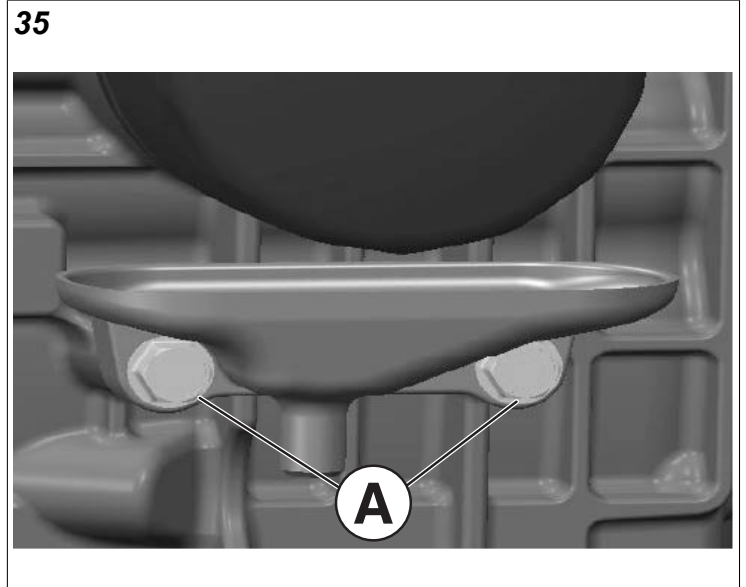
Oil Diverter Valve and Drip Tray

1. Rotate hex (A, Figure 34) to release adapter (B) and diverter (C) from crankcase flange.



2. Remove o-ring (D) from diverter groove.

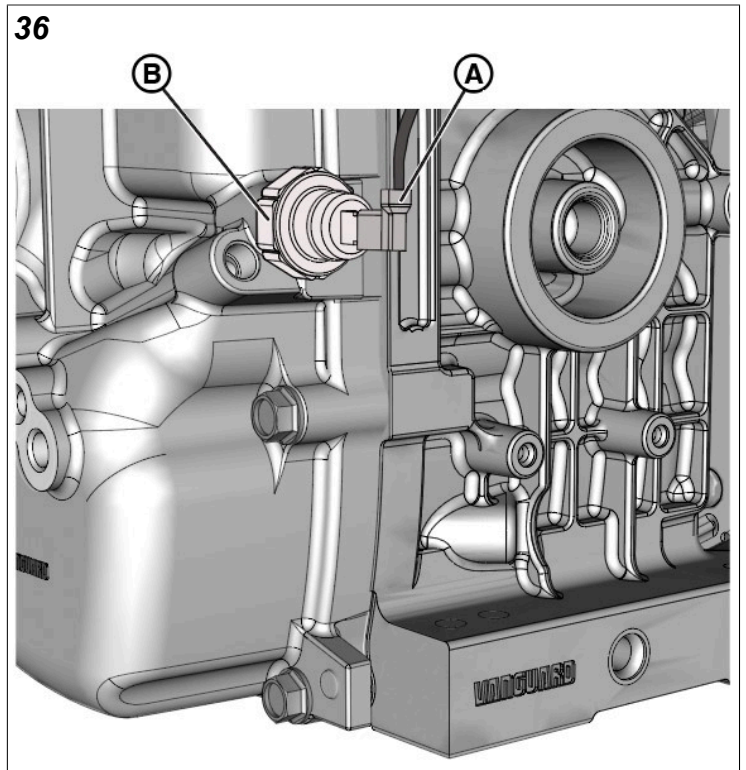
3. If equipped, remove the 2 fasteners (A, Figure 35) that secure the oil drip tray to the engine block.
4. Remove the drip tray from the engine block and set aside.



Oil Pressure Switch

1. Remove the electrical connector and wire from the oil pressure switch terminal (A, Figure 36).
2. Remove the oil pressure switch from the engine (B).

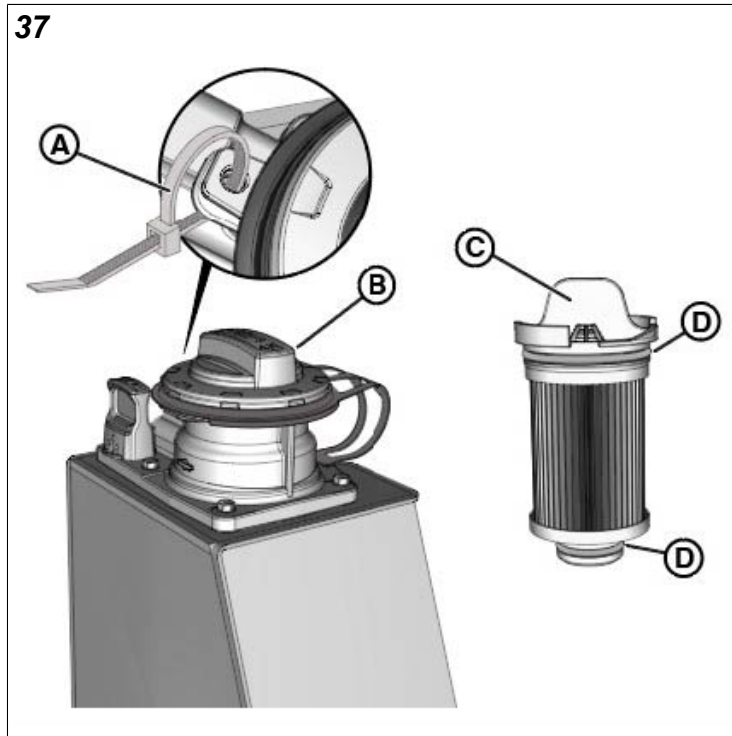
NOTE: Wrap a shop towel around the oil pressure switch to catch any residual engine oil.



Optional Oil Guard System

This section describes the procedure for removal of the Oil Guard System scavenge, supply and vent lines as well as the engine mounted fittings. Depending on your equipment specification, the Oil Guard oil tank may be mounted to the equipment. If so, consult your equipment repair manual for removal steps and procedures.

1. If present, cut cable strap (A, Figure 37) or remove other locking device to release oil fill cap (B) from oil filter housing.



2. Rotate oil fill cap ¼ turn to unlock. Remove cap from oil filter housing.
3. Remove oil drain hose from retaining clip, if present.
4. Rotate drain hose cap ¼ turn to unlock. Remove cap and drain oil into an approved container.
5. Grasp tab (C) and rotate oil filter ¼ turn to unlock. Remove oil filter from oil filter housing. Discard oil filter.

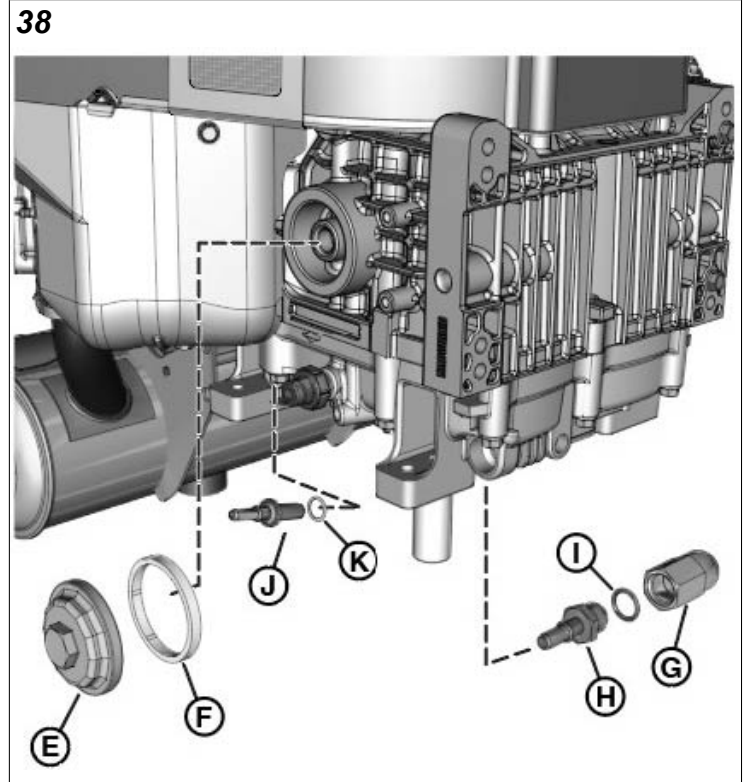
NOTE: It is necessary to overcome the resistance of two o-rings (D) to free oil filter from oil filter housing.

6. Disengage blue clip lock and remove crankcase ventilation hose connector from oil tank fitting.

NOTE: Push on both ends of clip lock at the same time to unlock hose connector. If connector is a tight fit, disengage slots on each end of clip lock from tabs in housing before pushing.

7. Disengage red clip lock and remove oil scavenge hose connector from oil tank fitting.
8. Disengage green clip lock and remove oil supply hose connector from oil tank fitting.
9. If the oil tank is engine mounted, remove 2 screws with hex nuts and flat washers to release oil tank and mounting bracket from crankcase.

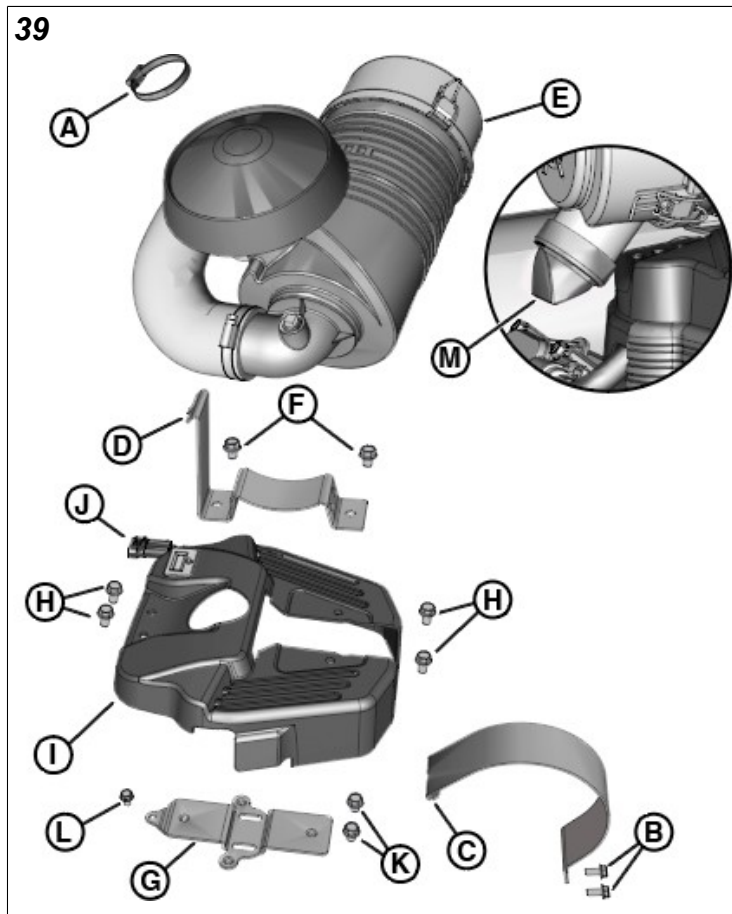
10. Disengage blue clip lock and remove crankcase ventilation hose connector from crankcase fitting.
11. Disengage green clip lock and remove oil supply hose connector from crankcase cover fitting farthest from the cylinder heads.
12. Holding the oil supply check valve (G, Figure 38) with a 25 mm wrench, remove the oil supply hose fitting (H) with a 22 mm socket. Remove o-ring (I) from fitting or check valve bore. Discard o-ring.



13. Remove the oil supply check valve from the engine bore.
14. Disengage red clip lock and remove oil scavenge hose connector from crankcase cover fitting (J) closest to the cylinder heads.
15. Remove the oil scavenge hose fitting with a 16 mm socket. Remove o-ring (K) from fitting or crankcase cover bore. Discard o-ring.
16. Remove oil bypass cover (E) and seal ring (F) from crankcase. Discard seal ring.

Air Cleaner Assembly - Cyclonic

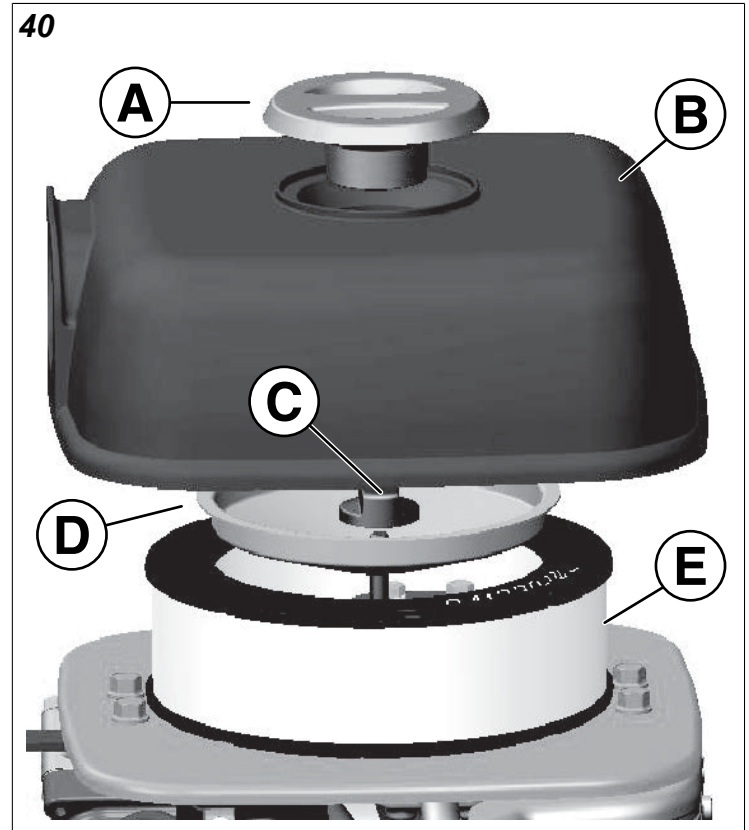
1. Loosen band clamp (A, Figure 39) and remove hose from air intake elbow.



2. Remove 2 fasteners (B) and disengage hook on air cleaner strap (C) from lip on air cleaner top bracket (D).
3. Remove air cleaner assembly (E).
4. Remove 2 fasteners (F) to release air cleaner top bracket from air cleaner bottom bracket (G).
5. Remove 4 fasteners (H) to release top cover (I) from air intake elbow and air cleaner bottom bracket. If equipped, disconnect MIL/ tachometer/hour meter connector (J) at back of top cover.
6. Remove 2 fasteners (K) to release air cleaner bottom bracket from fuel pump module bracket support.
7. Remove fastener (L) to release air cleaner bottom bracket from air intake elbow.
8. Remove duckbill air valve (M) on air inlet port of air cleaner cover. Look for cuts, tears, holes, or general deterioration.

Air Cleaner Assembly - Low Profile

1. Unscrew the air cleaner cover cap (A, Figure 40).



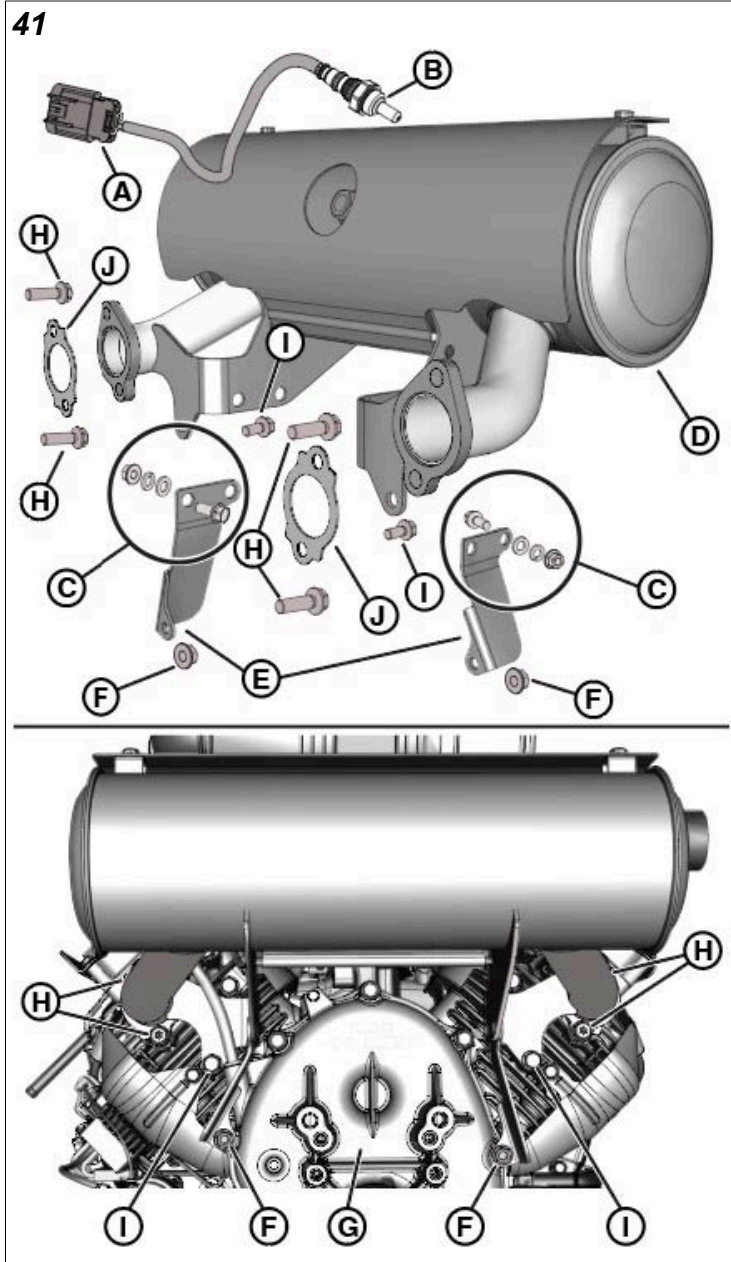
2. Remove the air cleaner cover (B).
3. Unscrew the air filter plate knob (C).
4. Remove the air filter plate (D).
5. Remove air filter (E) from air filter base plate.

NOTE: The air cleaner base is secured to a support bracket with either 2 or 4 fasteners (depending on application) as well as the throttle body, on EFI and EFI-ETC models, the carburetor or mixer. The fasteners serve to also secure these components to the intake manifold or intake elbow. For removal instructions see *Throttle Body, Carburetor and Spacers*, or *Mixer and Spacers* in this section, depending on your application.

Muffler

1. Disconnect HO₂ sensor connector (A, Figure 41), if equipped.

NOTE: If necessary, rotate sensor body hex counter-clockwise to remove HO₂ sensor (B) from muffler.



2. If equipped with optional muffler bracket support, proceed as follows:
 - A. Remove fastener, flat washer, lock washer, and hex nut (C) to release muffler (D) bracket from bracket supports (E).
 - B. Remove 2 fasteners (F) to release bracket supports from crankcase cover (G) studs.

3. Remove 2 fasteners (H) to release muffler manifolds from cylinder heads.

NOTE: Depending on your engine model and trim, the muffler manifold to cylinder head fastener may be replaced with studs and nuts.

4. Remove 2 fasteners (I) to release muffler bracket from crankcase.
5. Remove and discard muffler gaskets (J).

NOTE: Make sure that all remaining exhaust manifold gasket material is removed from the cylinder head mounting surface and the muffler mounting surface. All surfaces must be clean, dry and free from dirt, debris, and old gasket material.

Engine Covers

There are 2 engine covers, which are identified here as the key switch cover and the air intake elbow cover.

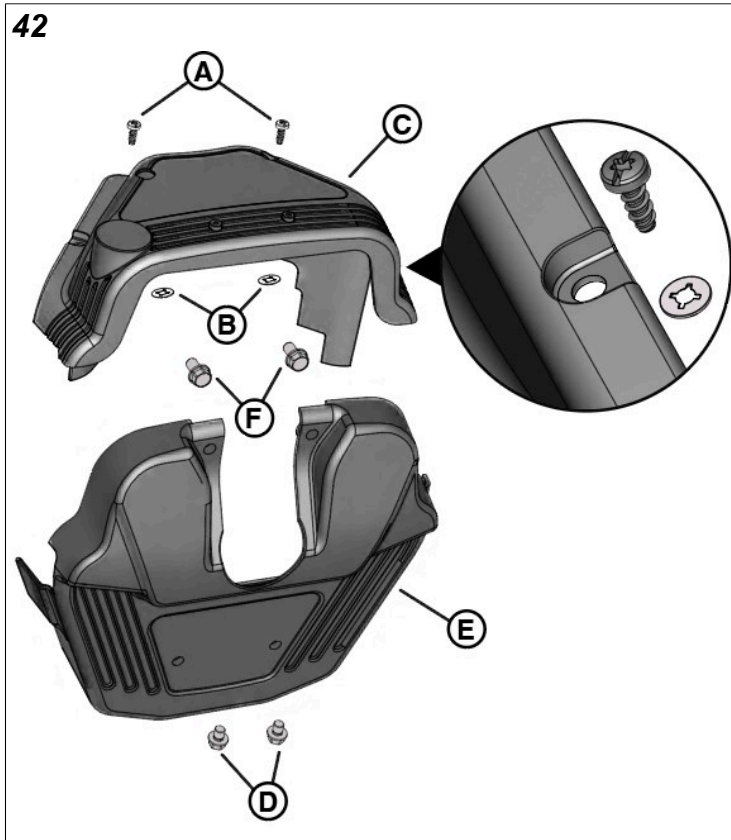
The key switch cover serves as the housing for the ignition key switch and/or throttle lever, if equipped, and is always fastened to the blower housing. The air intake elbow cover has a contoured opening to accommodate the air intake elbow, and is variously fastened to other bracketry or components, such as the fuel pump module bracket, air cleaner bracket, air intake elbow, etc.

The air intake elbow cover is absent on those models equipped with the low profile air cleaner.

Cover appearance may differ based on model and/or options.

Key Switch Cover

1. Remove 2 fasteners (A, Figure 42) with retaining washers (B) to release key switch cover (C) from blower housing.

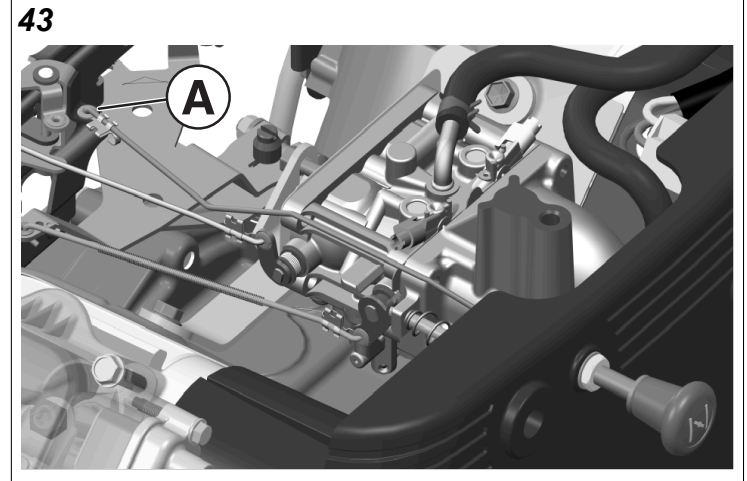


2. If equipped, disconnect the ignition key switch connector at the back of the cover.

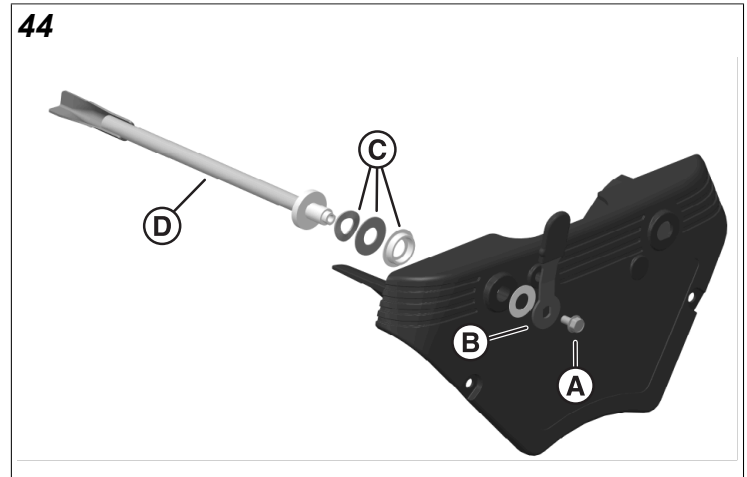
NOTE: Depending on your engine's model, trim and type, a number of throttle lever options exist. If your engine is equipped with a rotary-style throttle lever, and a push-pull choke, proceed to step 3. If your engine is equipped with a detent-style throttle lever, see *Throttle Control* in this section.

3. If your engine is equipped with cover mounted throttle and choke controls, proceed as follows:

4. Disconnect the choke rod from the speed control bracket (A, Figure 43) by releasing the retaining clip and removing the rod from the bushing hole.



5. Undo the jam nut on the back of the key switch cover. Remove the nut and lock washer. Pull the choke rod through the front of the key switch cover.
6. Remove the throttle lever fastener (A, Figure 44) from the throttle lever shaft.



7. Remove the throttle lever and washer (B) from the front of the key switch cover.
8. While removing the key switch cover from the engine, take care to capture the throttle lever washers between the speed control shaft and the cover (C).
9. Remove the speed control shaft (D) from the speed control bracket.

Intake Elbow Cover

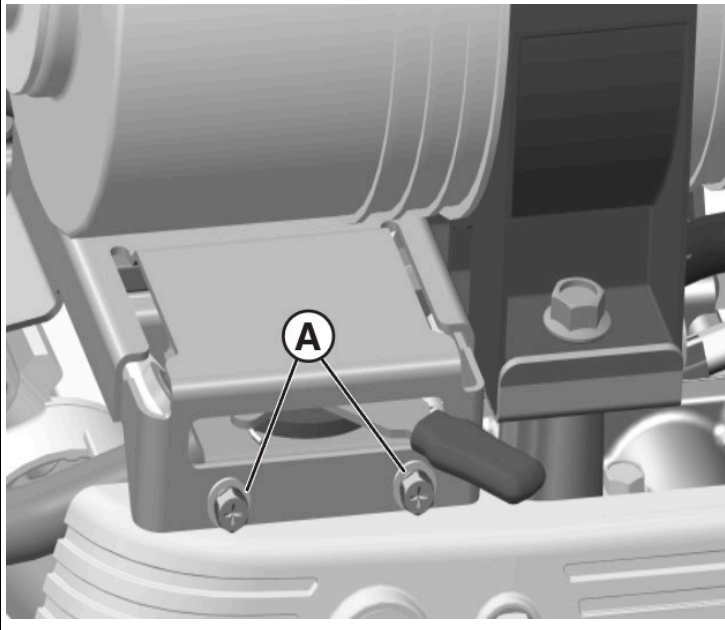
1. Remove 2 fasteners (D, Figure 42) to release air intake elbow cover (E) from fuel pump module bracket.
2. Remove 2 fasteners (F) to release cover from the air cleaner bracket.
3. If equipped, disconnect MIL/tachometer/hourmeter connector at back of cover.

Throttle Control

Depending on your engine's model and trim, a manual detent throttle may be equipped. For engines equipped with a Cyclonic Air Cleaner assembly, the throttle control may be mounted above the key switch cover at the front of the engine. For engines equipped with a Low-Profile Air Cleaner assembly, the throttle control may be remotely mounted. For engine mounted throttle controls, proceed as follows. For remote mounted throttle control, see your equipment's repair manual for removal instructions.

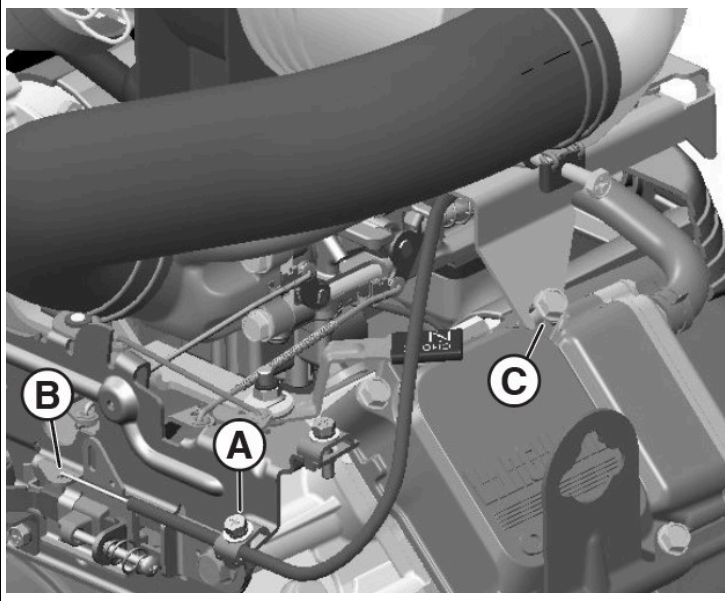
1. Remove the 2 fasteners (A, Figure 45) that secure the throttle control to the support bracket.

45



2. Remove the throttle cable clamp fastener (A, Figure 46) from the speed control bracket to release the throttle cable.

46



3. Remove the "Z" bend of the throttle cable (B) from the hole in the speed control bracket.

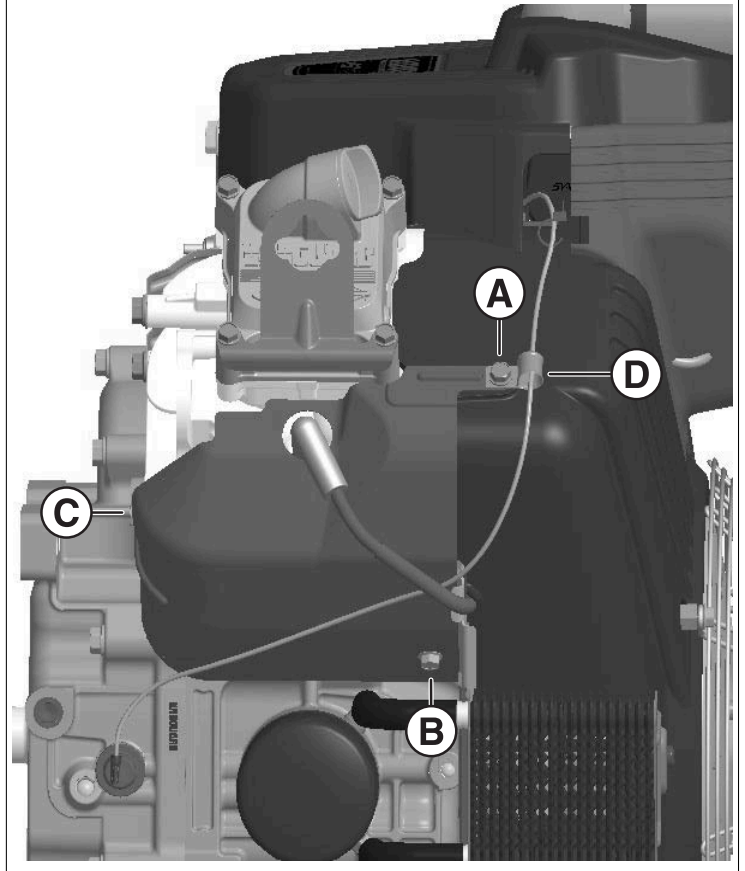
NOTE: The support bracket that houses the throttle control also serves as the air cleaner support bracket. An additional fastener (C, Figure 46) must be removed to release the support bracket from the engine.

Cylinder Air Guides

1. On the oil filter side of the engine, remove the 3 fasteners (A, B, C, Figure 47) that secure the cylinder air guide to the engine.

NOTE: A wire routing clamp (D) is installed on the top air guide mount. The oil pressure switch wire is secured by the wire clamp and the clamp is secured by the air guide mounting fastener. Take note of the clamp position and wire routing for reassembly.

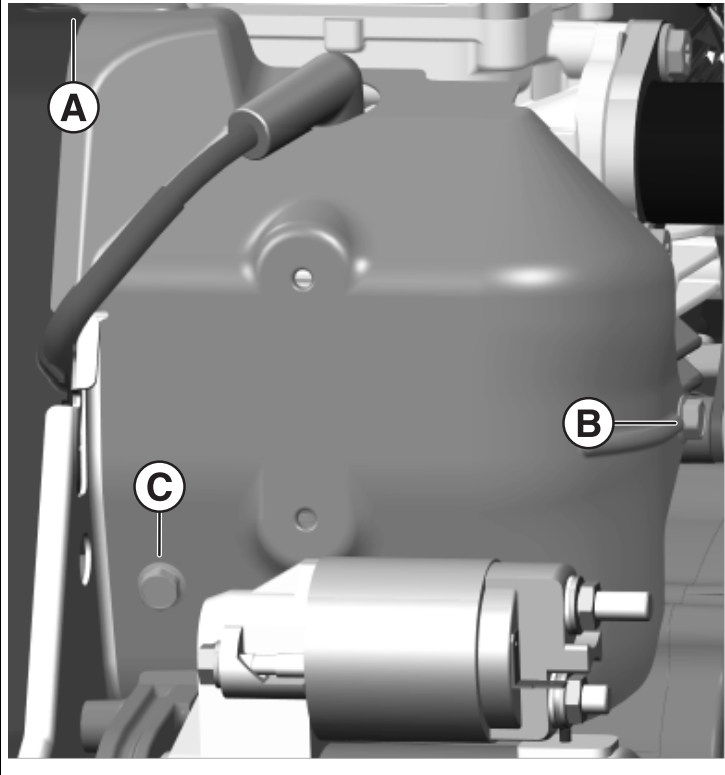
47



2. Remove air guide from engine and set aside.

3. On the starter motor side of the engine, remove the 3 fasteners (A, B, C, Figure 48) that secure the cylinder air guide to the engine.

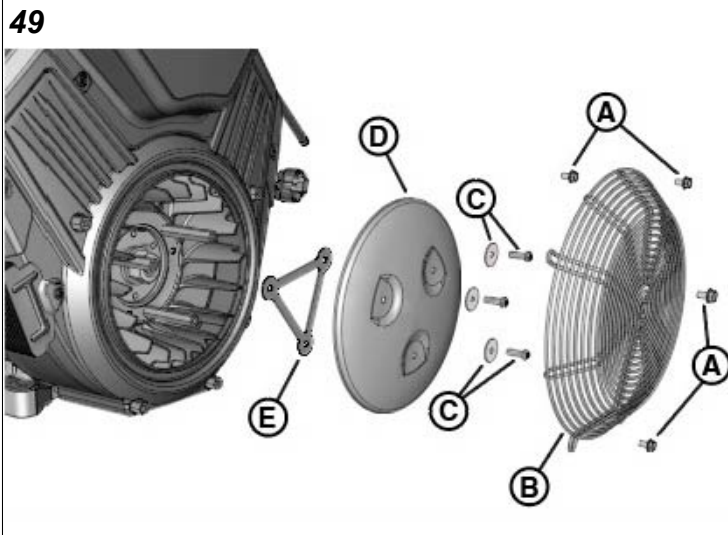
48



4. Remove the air guide from the engine and set aside.

Blower Housing

1. Remove 4 fasteners (A, Figure 49) to release wire guard (B) from coupling nuts.



2. Remove 3 fasteners with flat washers (C) to release debris screen (D) and triangular spacer (E) from rotating studs.
3. Remove 4 coupling nuts (F, Figure 50) from cylinder posts.

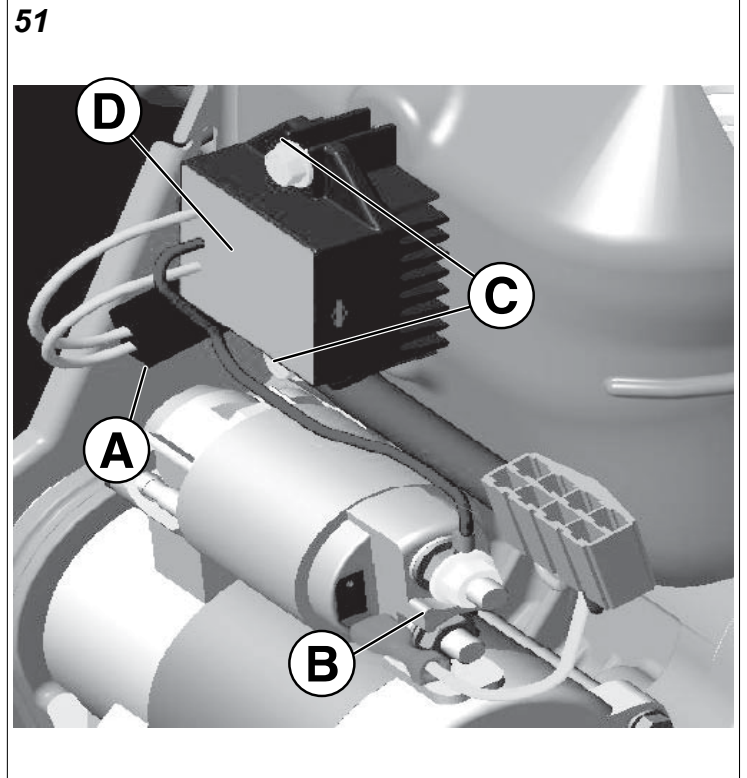


4. Remove blower housing (G) from engine and set aside.

Voltage Regulator

Your engine may be equipped with either a 20 amp or a 20/50 amp voltage regulator. The 20/50amp voltage regulator has a capacitor mounted to a bracket atop the regulator.

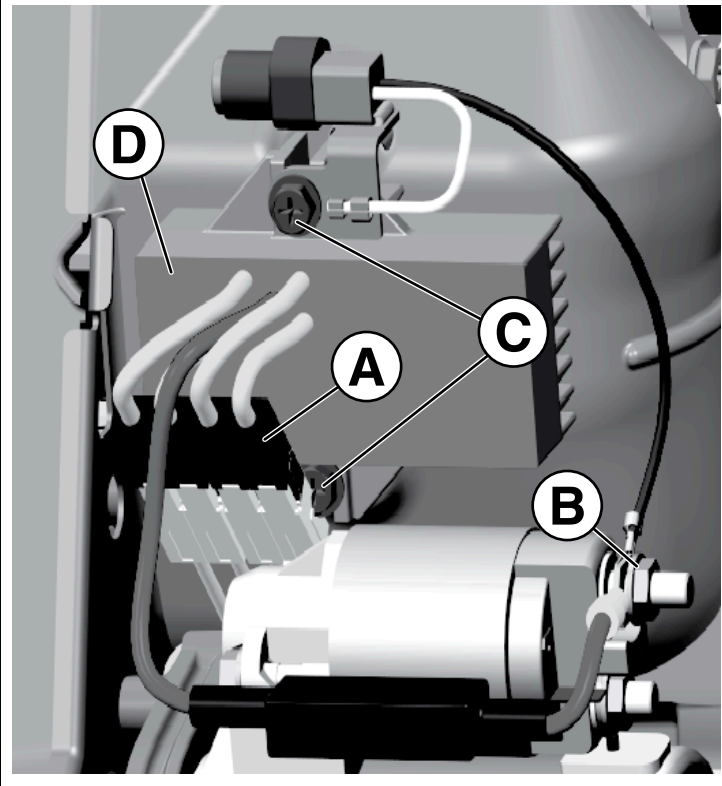
1. Disconnect the voltage regulator to stator connector. If equipped with a 20 amp regulator, see (A, Figure 51). if equipped with a 20/50 amp regulator, see (A, Figure 52).



2. Remove the starter motor positive terminal nut and then remove the voltage regulator wire from the terminal. 20 amp voltage regulator, see (B, Figure 51). The 20/50 amp voltage regulator has an additional wire, the capacitor wire, that connects to the starter motor positive terminal, see (B, Figure 52).
3. Remove the 2 voltage regulator mounting fasteners (C, Figure 51 and Figure 52).

- Remove the voltage regulator (**D**, Figure 51 and Figure 52) from the engine and set aside.

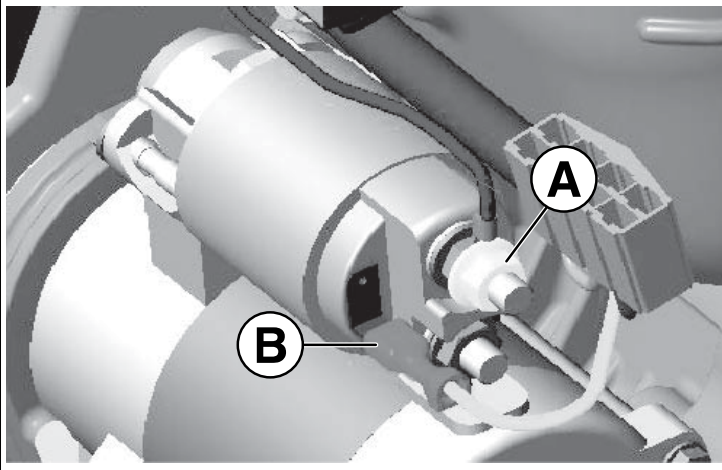
52



Starter Motor

- Remove starter motor positive terminal nut (**A**, Figure 53) and remove the wires from the terminal.

53

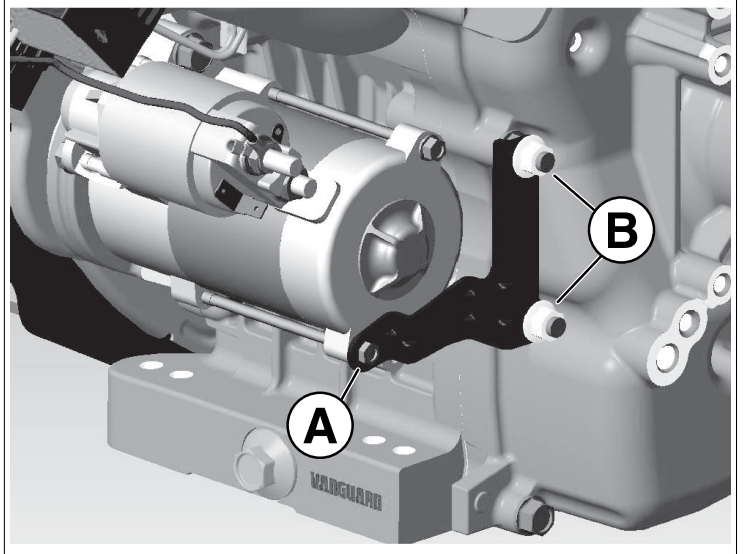


- Remove the ignition start switch wire (**B**) from the starter solenoid terminal.

NOTE: Some engines may be equipped with a starter motor support bracket. Removal of this bracket is required for starter motor removal. If equipped, proceed to steps 3 and 4. If your engine is NOT equipped with a starter motor support bracket, skip to step 5.

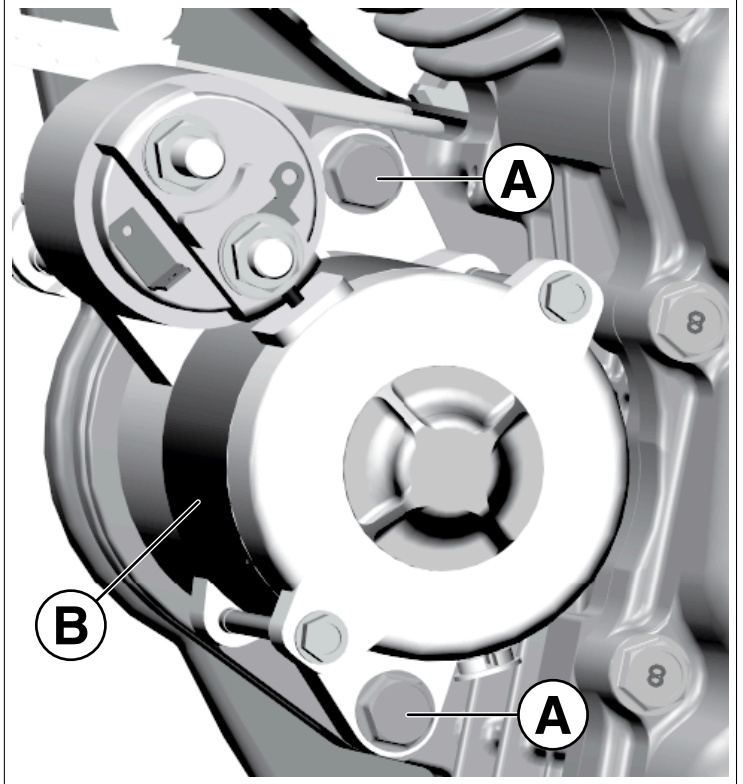
- If equipped, remove the starter motor support bracket to starter motor bolt (**A**, Figure 54).

54



- Remove the 2 starter motor support bracket to engine block nuts (**B**).
- Remove the 2 starter motor mounting fasteners (**A**, Figure 55).

55

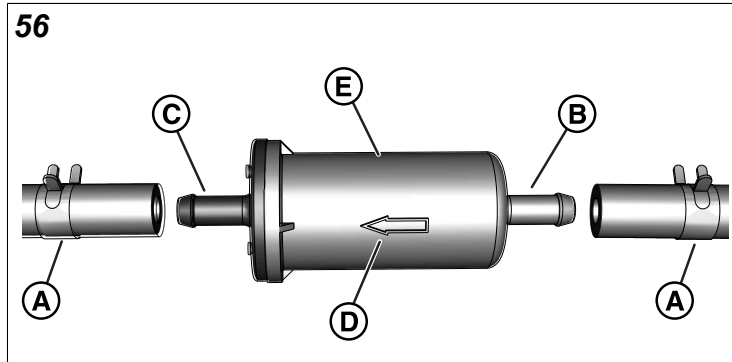


- Remove the starter motor (**B**) from the engine and set aside.

Fuel Filter

1. Squeeze tangs and move hose clamps (A, Figure 56) away from fuel inlet (B) and outlet (C) fittings. Remove fuel inlet and outlet hoses from fuel filter (E) fittings.

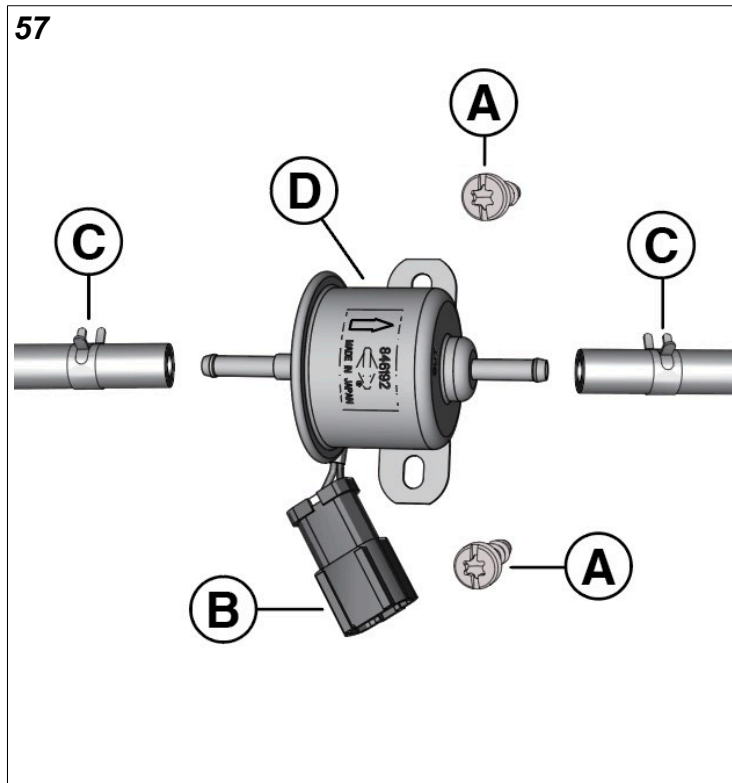
NOTE: Wrap shop towel around fuel filter to catch any fuel leakage



2. Remove and dispose of the fuel filter in the proper receptacle.

Electric Lift Fuel Pump

1. Remove the two fasteners (A, Figure 57) to release electric lift fuel pump bracket from lifting bracket.



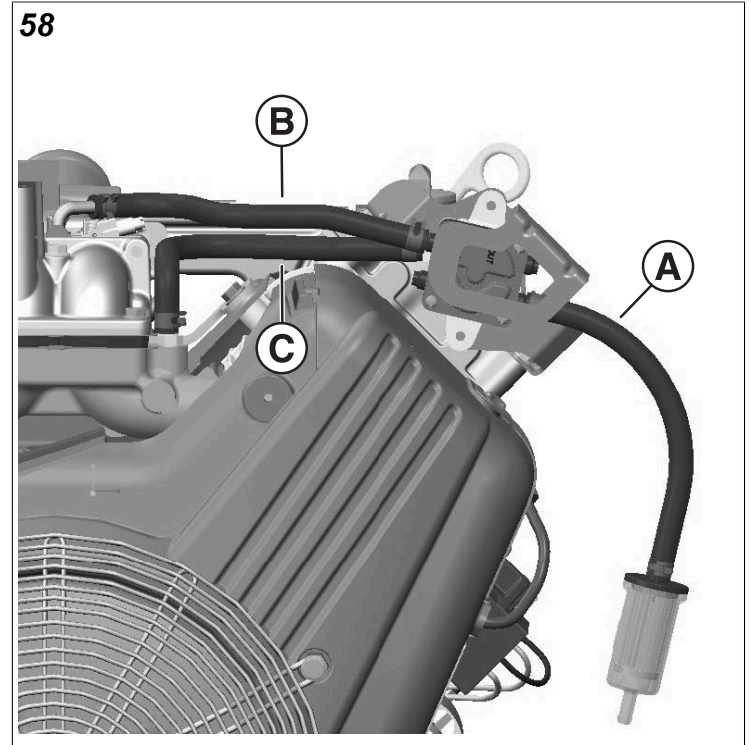
2. Disconnect fuel pump connector (B).
3. Squeeze the tangs of the fuel line clamps (C) and move away from fuel inlet and outlet fittings. Remove fuel inlet and outlet hoses from the lift pump (D).

NOTE: Wrap shop towel around fuel filter fittings to catch any fuel leakage.

4. Remove fuel lift pump and set aside.

Fuel Pump - Carbureted Engine

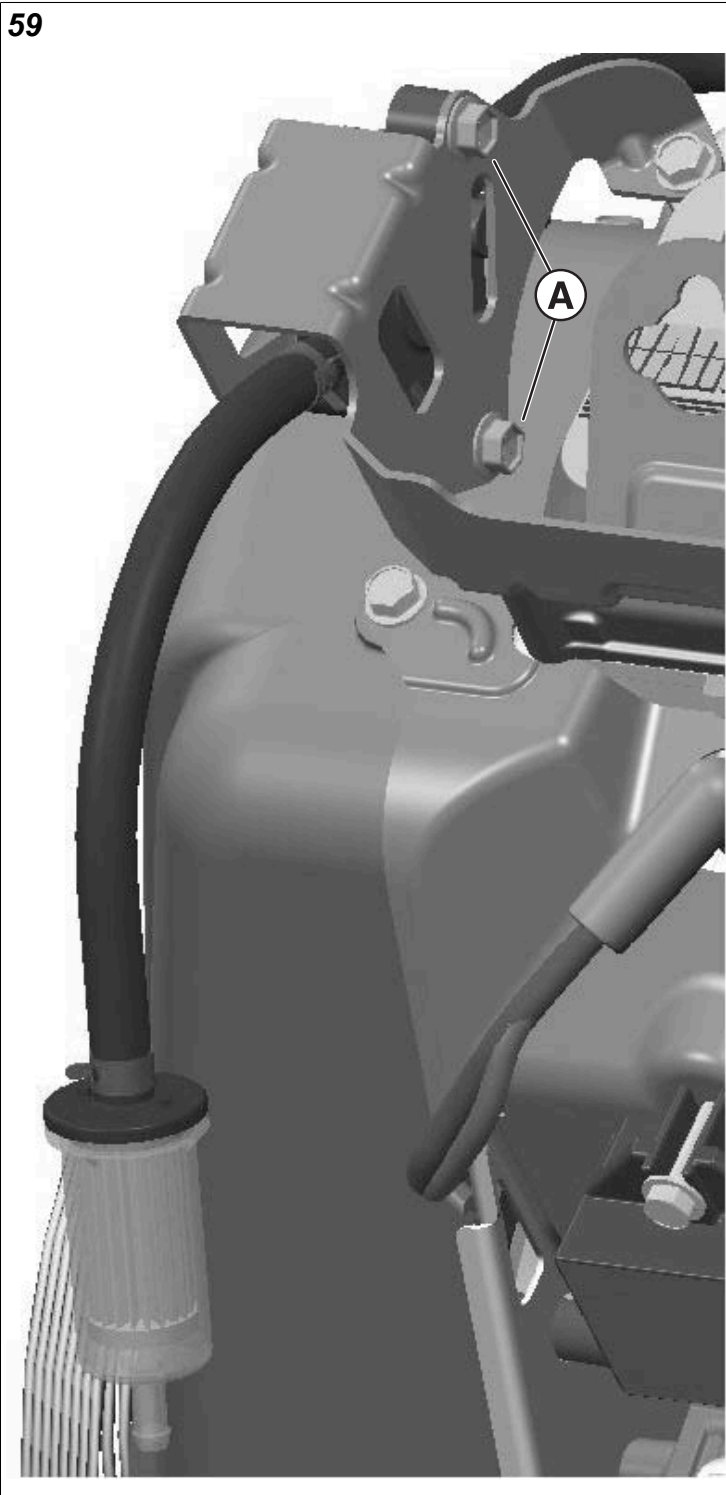
1. Squeeze tangs and move hose clamp on the fuel feed line (A, Figure 58) away from the fuel pump.



2. Remove the fuel feed line from the fuel pump.
3. Squeeze tangs and move the hose clamp (B) away from the fuel inlet on the carburetor.
4. Remove the fuel pump outlet to carburetor line from the carburetor.
5. Squeeze tangs and move the hose clamp (C) away from the vent line on the intake manifold.
6. Remove the vent line from the intake manifold.

7. Remove the 2 fasteners (A, Figure 59) that secure the fuel pump to the fuel pump bracket.

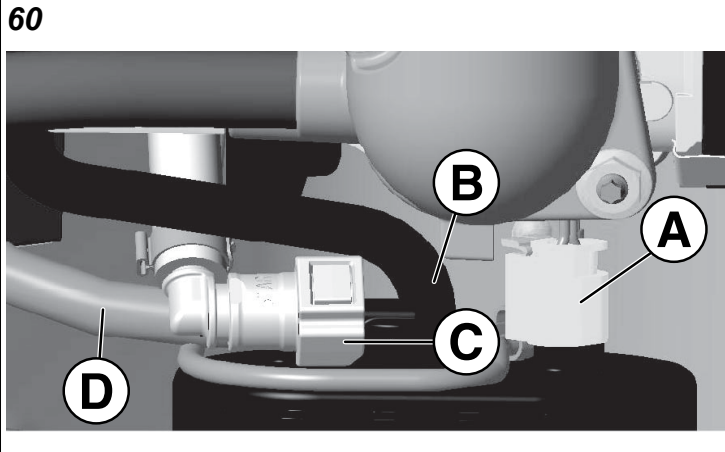
59



8. Remove the fuel pump and set aside.

Fuel Pump Module

1. Disconnect the fuel pump module electrical connector (A, Figure 60). Lift the tab within the connector then remove the connector from the fuel pump module.

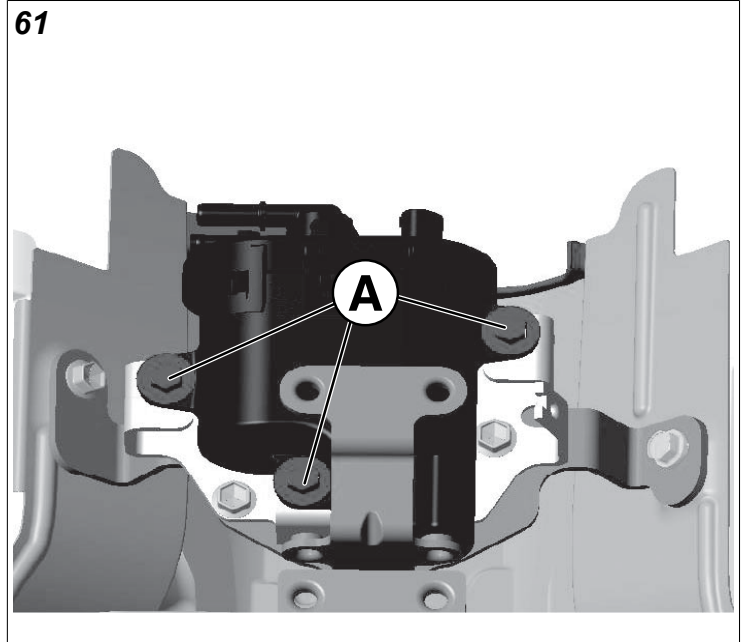


2. Remove the fuel vent line (B) from the fuel pump.
 - a. Squeeze the tangs on the vacuum line clamp and slide along hose away from the module.
 - b. Remove the vacuum line from the module.
3. Remove the fuel feed line (C) to the injectors.
 - a. Depress the tabs on either side of the fuel line connector.
 - b. With the tabs depressed, pull the fuel line off of the fuel pump module port.

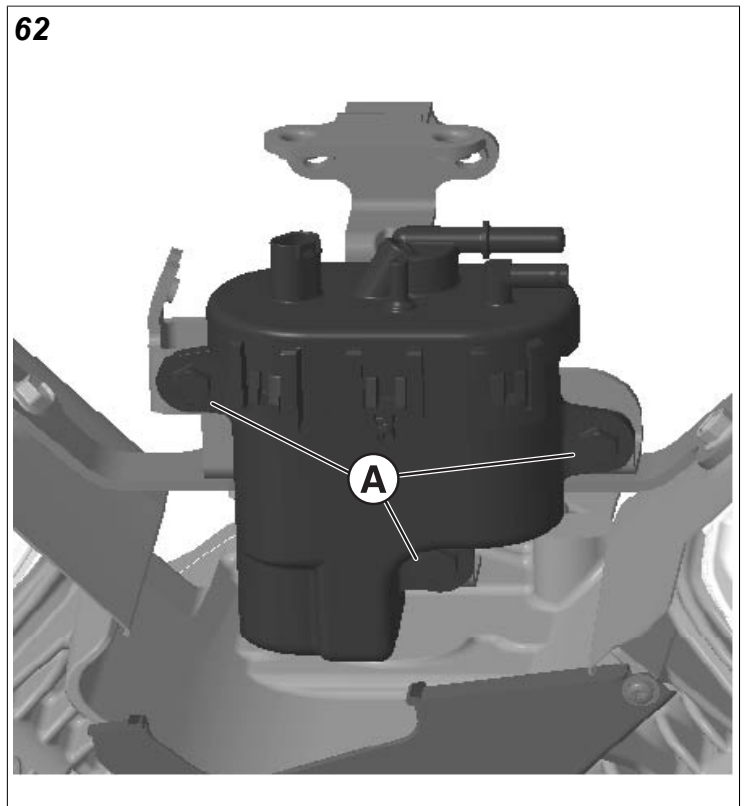
NOTE: Wrap a shop towel around the fuel lines (feed and supply) to catch any fuel spillage.

4. Remove the fuel supply line (D) from the lift pump to the fuel pump module.
 - a. Squeeze the tangs on the fuel supply line clamp and slide along the hose away from the fuel pump module.
 - b. Remove the fuel supply line from the fuel pump module port.
5. If your engine is a vertical-shaft engine, proceed as follows. If your engine is a horizontal-shaft engine, skip to step 7.

6. On a vertical-shaft engine, the fuel pump module to module mounting bracket bolts (A, Figure 61) are accessible at this point. Remove the 3 fuel pump module fasteners and set the fuel pump module aside.

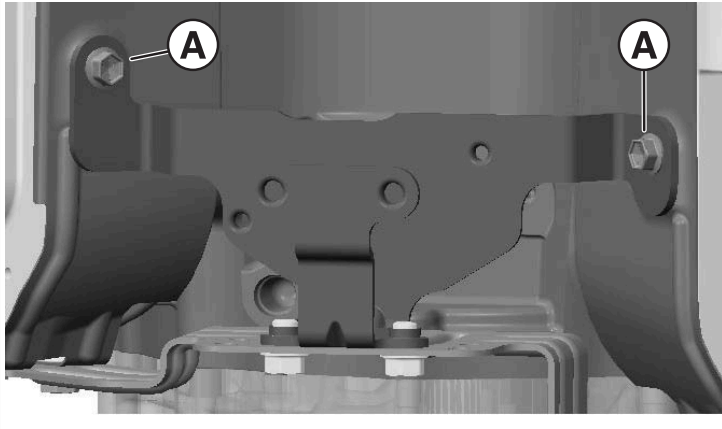


7. On a horizontal-shaft engine, remove the 3 fuel pump module bracket to support bracket fasteners.
8. Remove the 3 fuel pump module to module bracket fasteners (A, Figure 62). Set fuel pump module aside.



9. Remove the 2 fasteners securing the fuel pump module support bracket to the valley air guides (A, Figure 63). Set mounting bracket aside.

63



Engine Control Module (ECM) - EFI

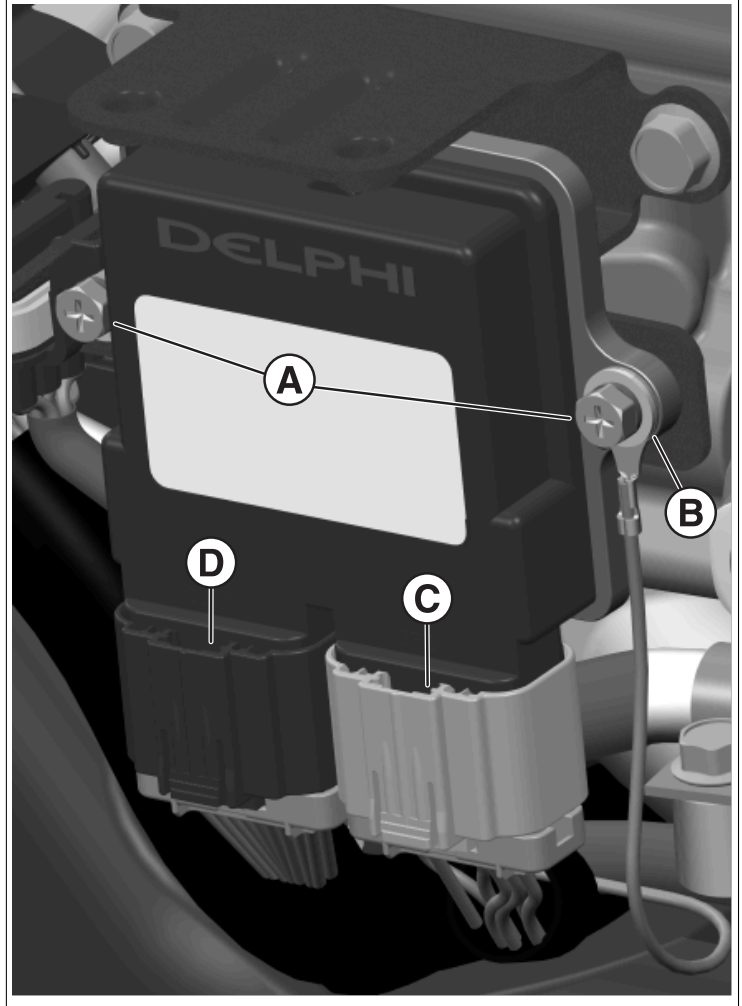
Some engines may have an ECM that is mounted externally to the engine.

1. Remove the 2 fasteners (A, Figure 64) and wire harness ground wire (B) that secure the ECM to the support bracket.

2. Remove the J1 (GRAY) (C) and J2 (BLACK) (D) harness connectors from the ECM by depressing the connector tab and pulling away from the ECM.

NOTE: Take note of the location of the J1 and J2 ECM connectors to maintain correct orientation during reassembly.

64

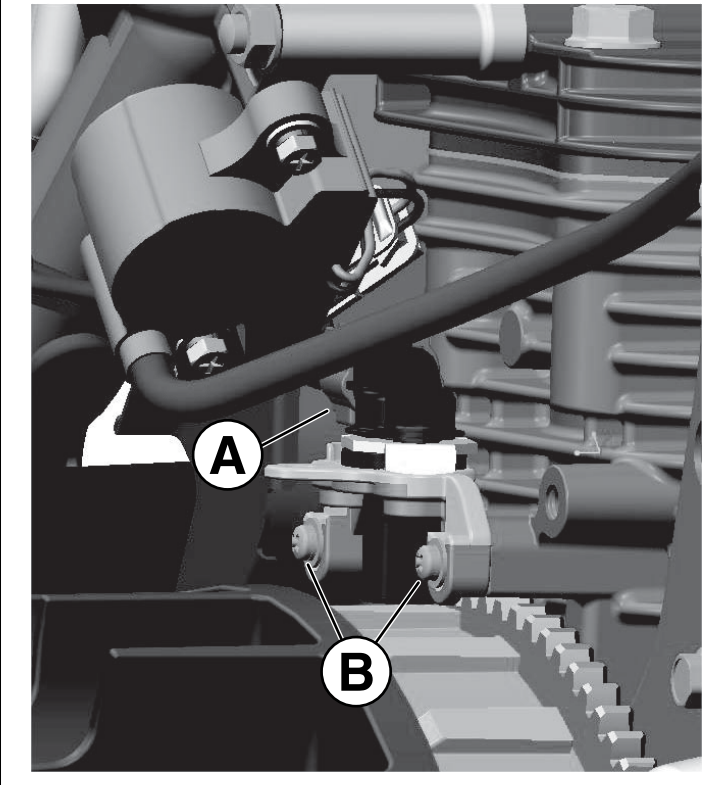


3. Remove ECM from engine and set aside.

Crankshaft Position Sensor (CKP)

1. Disconnect the crankshaft position sensor electrical connector (A, Figure 65).

65

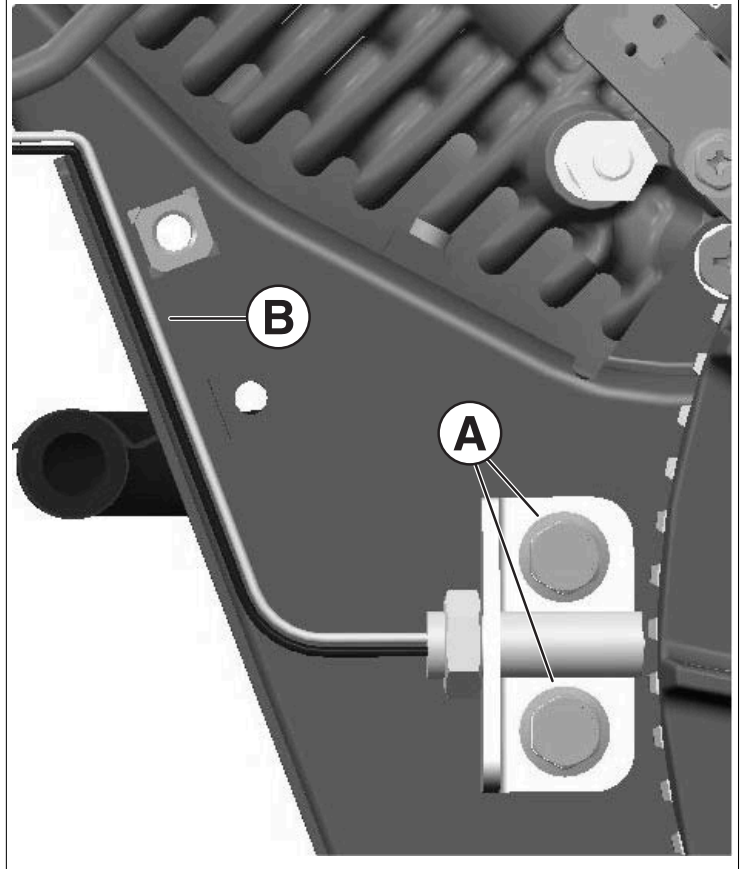


2. Remove the 2 crankshaft position sensor fasteners (B). Set sensor aside.

Optional Speed Sensor

1. Remove the 2 speed sensor fasteners (A, Figure 66) from the engine back plate mounting.

66

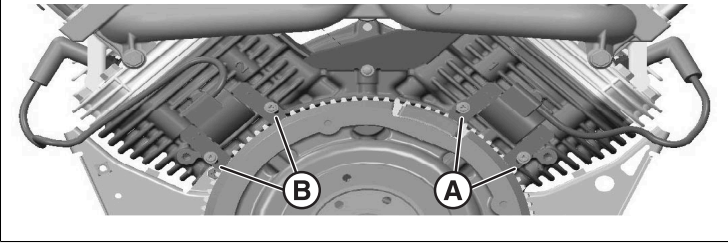


2. Remove the sensor wiring (B) from the back plate routing.
3. Disconnect the sensor electrical connector from the harness connector.
4. Set sensor aside.

Ignition Coil/Armature - Carbureted and Gaseous

1. Starting with the ignition coil/armature for cylinder 1, remove the 2 fasteners (**A**, Figure 67) that secure the ignition coil to the engine block.

67

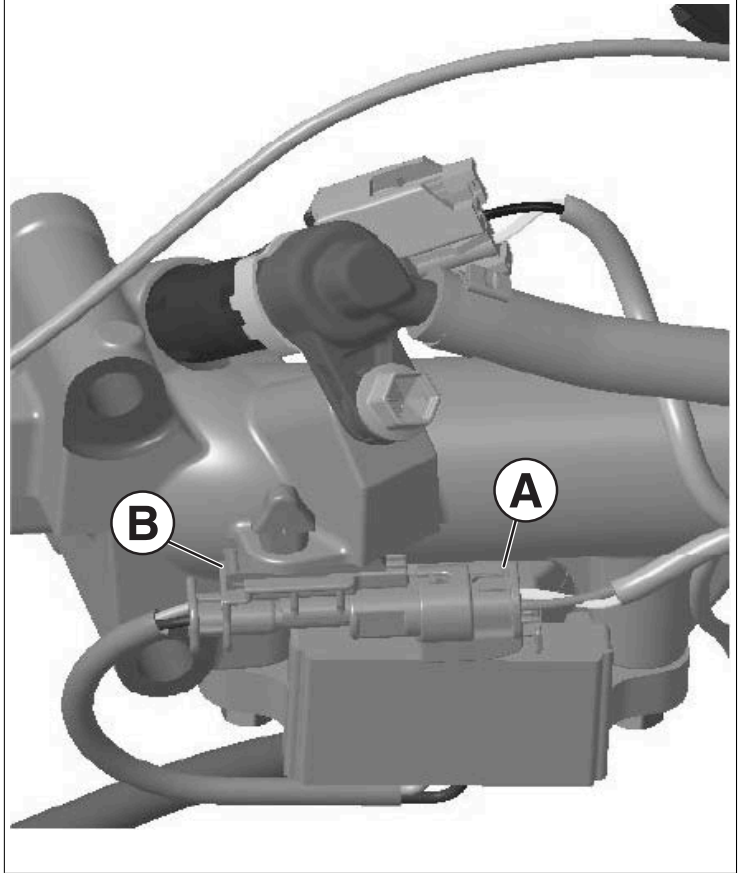


2. Set Ignition coil aside.
3. Remove the 2 fasteners (**B**) that secure the ignition coil on cylinder 2 to the engine block.
4. Set ignition coil aside.

Ignition Coil - EFI and EFI-ETC

1. Disconnect the engine wire harness connector from the ignition coil electrical connector (**A**, Figure 68).

68

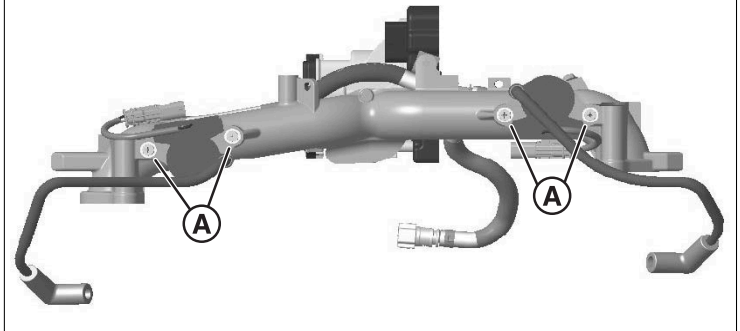


2. Remove the ignition coil electrical connector (**B**) from the intake manifold by depressing the tab and sliding the connector off of the mounting.

NOTE: DO NOT cut the ignition coil electrical connector mounting tab cable strap. The cable strap is used for wiring harness retention.

3. Remove the 2 fasteners (**A**, Figure 69) that secure the ignition coil to the intake manifold.

69



4. Repeat step 3 for second ignition coil.

Intake Elbow and Throttle Body Adapter - EFI

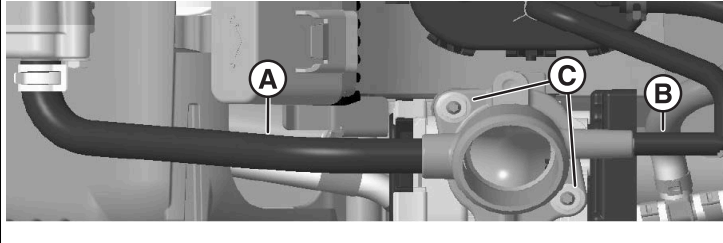
On engines equipped with a cyclonic air cleaner, an intake elbow is fitted. Follow the removal steps for the intake elbow.

On engines equipped with a low-profile air cleaner, a throttle body adapter is fitted. Follow the removal steps for the throttle body adaptor.

Intake Elbow Removal

1. Remove the crankcase breather hose from the valve cover to the intake elbow (**A**, Figure 70).

70



2. Remove the fuel vent line from the fuel pump module to the intake elbow (**B**).
3. Inspect hoses for cracks, tears and damage. Replace if necessary.
4. Remove the 2 fasteners (**C**) that secure the intake elbow to the throttle body assembly.

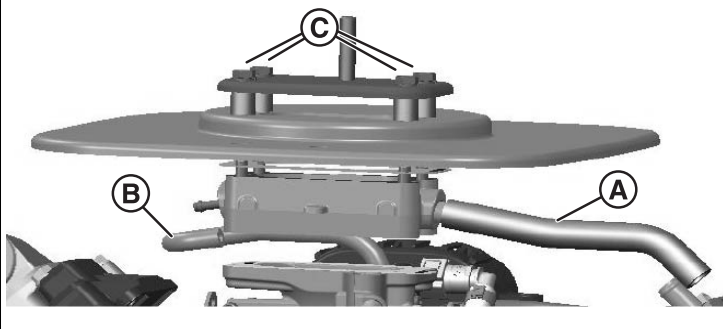
NOTE: Depending on your engine's trim, the intake elbow may be secured to the throttle body by either 2 or 4 fasteners. The removal procedure is the same regardless of the number of intake elbow fasteners.

5. Lift the intake elbow off of the throttle body assembly and set aside. Inspect the throttle body to intake elbow o-ring for damage and contamination. Replace if necessary.

Throttle Body Adapter Removal

1. Remove the crankcase breather hose from the valve cover to the throttle body adapter (**A**, Figure 71).

71



2. Remove the fuel vent line from the fuel pump module to the throttle body adapter (**B**).
3. The throttle body adapter is secured to the throttle body by the 4 air cleaner base plate fasteners. Remove the 4 air cleaner base plate fasteners (**C**).

4. Remove the air cleaner base plate to support bracket fasteners.

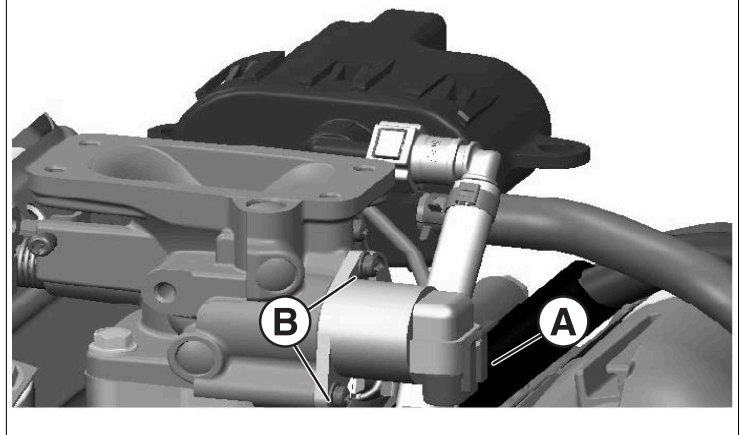
NOTE: Depending on your engine's trim, the air cleaner base plate may be secured to a support bracket with either 2 or 4 fasteners.

5. If equipped, remove the 2 fasteners that secure the ECM/ Fuse Block mounting bracket to the throttle body adapter.
6. Lift the throttle body adapter and gaskets off of the throttle body assembly and set aside. Discard old gasket.

Idle Air Control Valve (IAC) - EFI

1. Disconnect the IAC valve electrical connector (**A**, Figure 72).

72



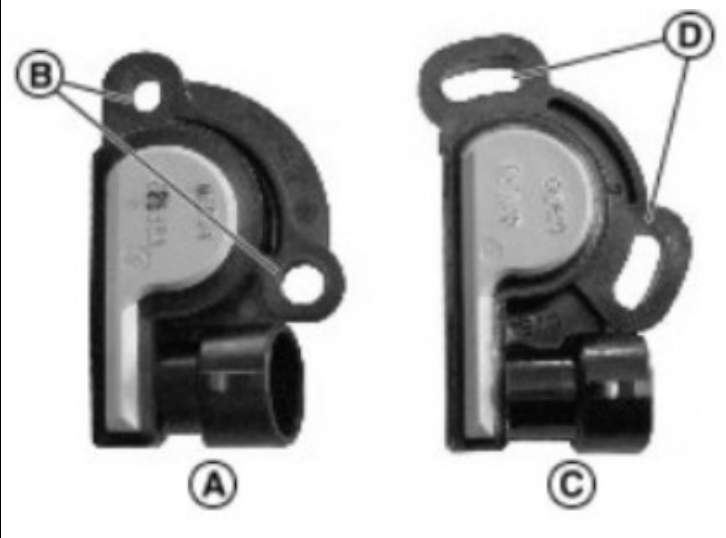
2. Remove the 2 fasteners (**B**) that secure the IAC valve to the throttle body.
3. Remove the IAC valve from the throttle body and set aside.

Throttle Position Sensor (TPS)

Depending on your engine's specification and production date, 2 styles of TPS may be equipped. The late style non-adjustable TPS (A, Figure 73) can be identified by the round fastener holes (B) in the mounting flange. The early style adjustable TPS (B) can be identified by the slotted fastener holes (D) on the mounting flange. Engines equipped with the late style TPS may also come equipped with a tamper proof TORX idle set screw.

2. Remove dead idle screw with spring from throttle body.
3. Mark throttle plate position for ease of installation.

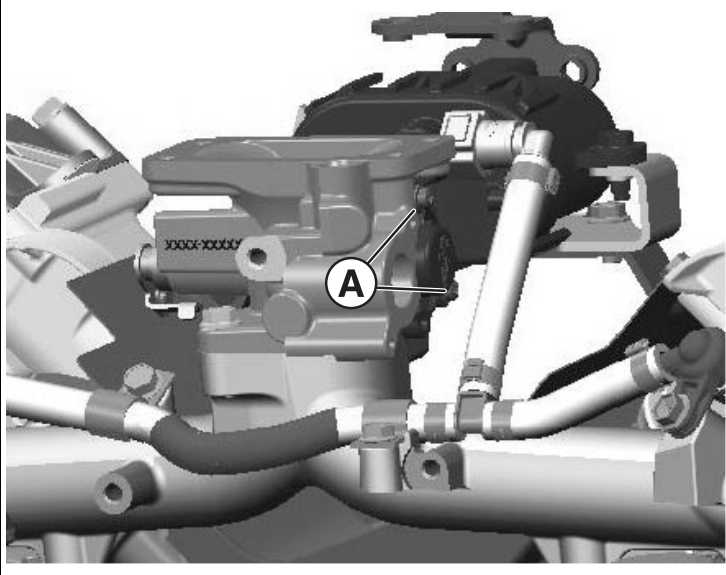
73



Throttle Position Sensor (TPS) - Late Style

1. Disconnect the wire harness to TPS electrical connector.
2. Remove the 2 fasteners (A, Figure 74) that secure the TPS to the throttle body.

74



3. Remove the TPS from the throttle body and set aside.

Throttle Position Sensor (TPS) - Early Style

1. Remove 2 fasteners to release TPS from throttle body.

Carburetor and Spacers

Your engine may be equipped with either a cyclonic air cleaner assembly or a low-profile air cleaner assembly. On engines equipped with a low-profile air cleaner, the air cleaner base makes use of 4 studs that secure the intake adaptor, carburetor, spacers and gaskets to the intake manifold. For this style of air cleaner, proceed to *Low Profile Air Cleaner Equipped Engines*, see Figure 76.

Engines equipped with a cyclonic air cleaner assembly will have an intake elbow that makes use of 4 studs to secure the carburetor, spacers and gaskets to the intake manifold. For this style of air cleaner, proceed to *Cyclonic Air Cleaner Equipped Engines*, see Figure 75.

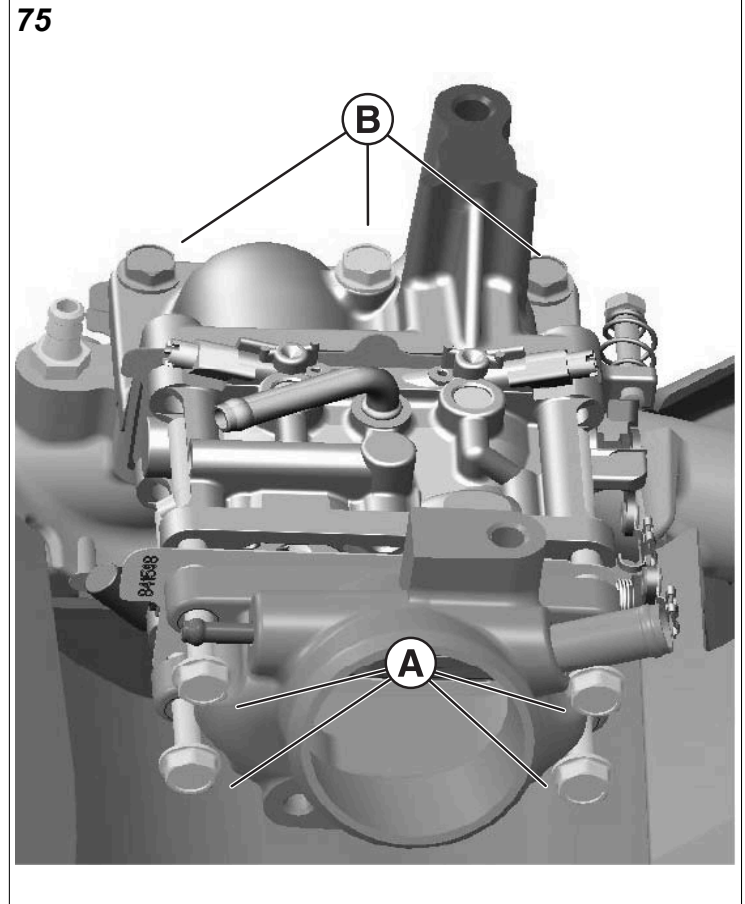
Cyclonic Air Cleaner Equipped Engines

1. Disconnect the valve cover breather hose from the carburetor.
2. Disconnect the fuel vent line at the intake elbow.
3. Disconnect the fuel feed line from the carburetor by squeezing the tangs of the clamp and sliding the clamp away from the carburetor. Remove the fuel line from the carburetor port using the Fuel Line Removal Tool. See *SECTION 3 - TROUBLESHOOTING - Special Tools List*.

NOTE: Wrap a shop towel around the fuel line during removal to catch any residual fuel in the line.

4. Disconnect the fuel pump vent line at the intake manifold port by squeezing the tangs of the clamp and sliding the clamp away from the intake manifold. Remove the line from the intake port. Use the fuel line removal tool, if necessary.
5. Disconnect the carburetor choke rod at the carburetor.
6. Disconnect the anti-afterfire solenoid electrical connector from the solenoid.

7. Remove the 4 fasteners that secure the carburetor (**A**, Figure 75) to the intake elbow. Remove the intake elbow and discard old gasket.



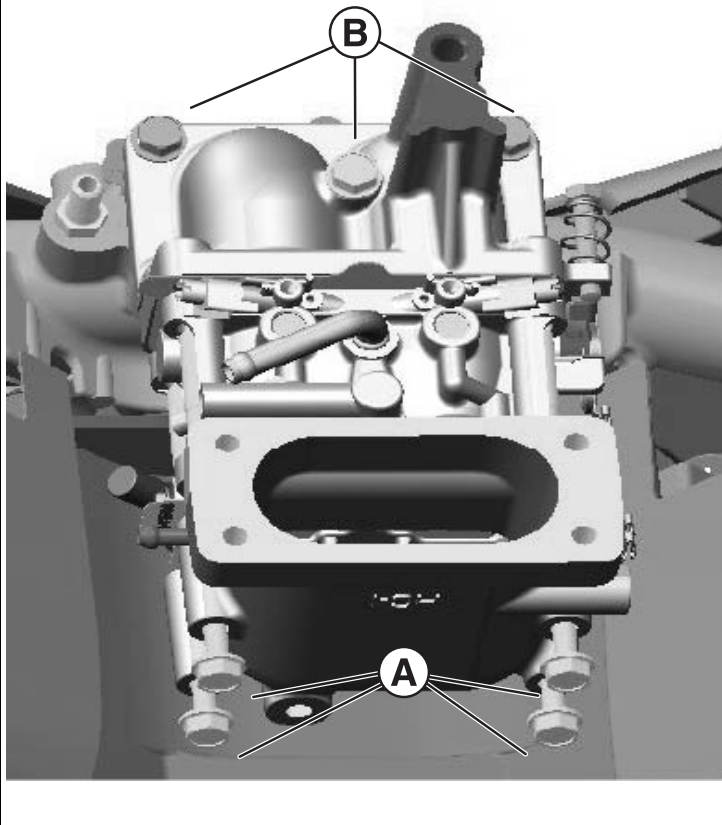
8. Lift the carburetor **SLIGHTLY** to allow for the disconnection of the throttle rod and spring. Undo the throttle rod clip and release the spring. Remove the throttle rod from the throttle lever at the carburetor.
9. Remove the carburetor from the engine.
NOTE: Place the carburetor in a container or on shop towels to capture any residual fuel.
10. Remove the gaskets and spacers between the carburetor and intake manifold (**Vertical Shaft** engines) or intake elbow (**Horizontal Shaft** engines).
11. On **Horizontal Shaft** engines, remove the 3 fasteners that secure the intake elbow to the intake manifold (**B**).
12. Remove the intake elbow from the intake manifold and discard old gasket.

Low-Profile Air Cleaner Equipped Engines

1. Follow steps 1-6 listed above.

2. Remove the 4 fasteners that secure the air cleaner base to the intake adaptor (**A**, Figure 76). Remove air cleaner base and discard old gasket.

76



3. Remove intake adaptor from carburetor. Discard old gasket.
4. Lift the carburetor **SLIGHTLY** to allow for the disconnection of the throttle rod and spring. Undo the throttle rod clip and release the spring. Remove the throttle rod from the throttle lever at the carburetor.
5. Remove the carburetor from the engine.
NOTE: Place the carburetor in a container or on shop towels to capture any residual fuel.
6. Remove the gaskets and spacers between the carburetor and intake manifold (**Vertical Shaft** engines) or intake elbow (**Horizontal Shaft** engines).
7. On **Horizontal Shaft** engines, remove the 3 fasteners that secure the intake elbow to the intake manifold (**B**).
8. Remove the intake elbow from the intake manifold and discard old gasket.

Anti-Afterfire Solenoid

1. Disconnect the wire harness connector from the anti-afterfire solenoid.
2. Unscrew the anti-afterfire solenoid from the carburetor bowl by turning the solenoid in a counter-clockwise direction.

NOTE: Wrap the solenoid with a shop towel to capture any spilled fuel. Dispose of fuel in an appropriate receptacle.

Mixer and Spacers - Gaseous

1. Disconnect the valve cover breather from the spacer.
2. Disconnect the fuel feed line from the mixer by squeezing the tangs of the clamp and sliding the clamp away from the mixer. Remove the fuel line from the carburetor port using the Fuel Line Removal Tool. See *SECTION 3 - TROUBLESHOOTING - Special Tools List*.
3. Remove the air cleaner base to support bracket fasteners.
4. Remove the 4 air cleaner base plate and mixer shield fasteners.

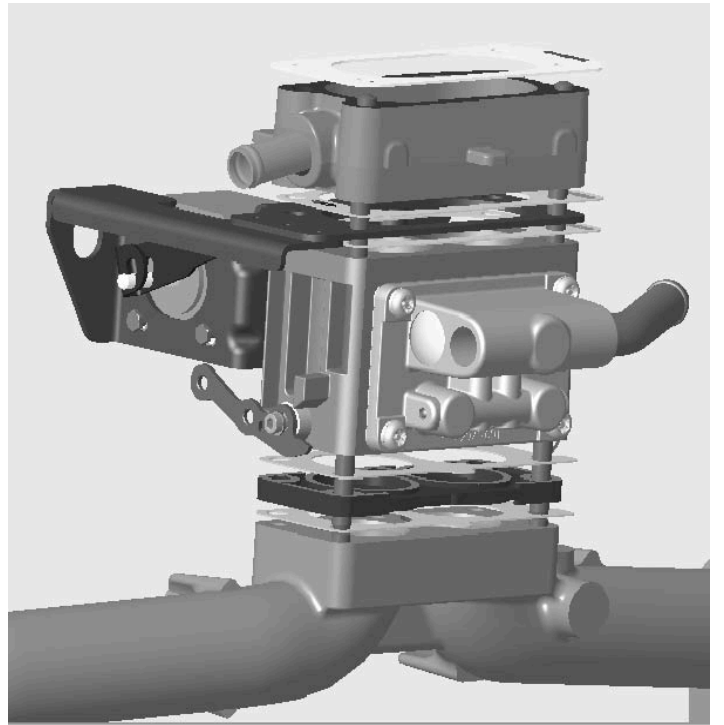
NOTE: Depending on the configuration of your engine, the air cleaner base may be attached with 4 bolts or 2 bolts and 2 studs with nuts.

5. Remove the air cleaner base and set aside. Discard old gasket.
6. Disconnect the governor link rod and spring from the throttle lever. Release the link rod clip, release the spring, and remove the link rod from the throttle lever bushing hole.
7. On engines equipped with a **Stepper Motor**, disconnect the governor link from the stepper motor by removing the clip from the clevis.
8. On engines equipped with the optional **Actuator**, disconnect the actuator link and spring from the throttle lever. Release the clevis clip, release the spring, and remove the end of the actuator link from the bushing hole of the throttle lever.

NOTE: The actuator assembly is attached to the support bracket. To remove the actuator from the engine, remove the fasteners between the actuator and the support bracket.

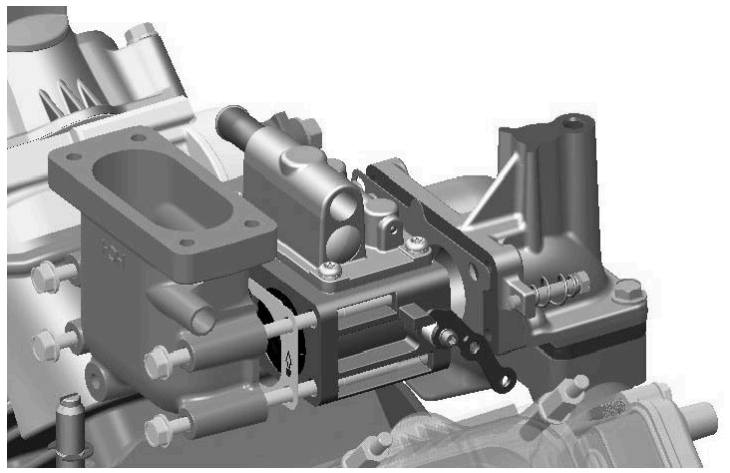
9. On **vertically-mounted** mixers, remove the spacer from the mixer or stepper motor bracket (if equipped). Discard old gasket. See Figure 77.

77



10. On **horizontally-mounted** mixers, remove the 4 intake elbow fasteners. Remove intake elbow and discard old gasket. See Figure 78.

78

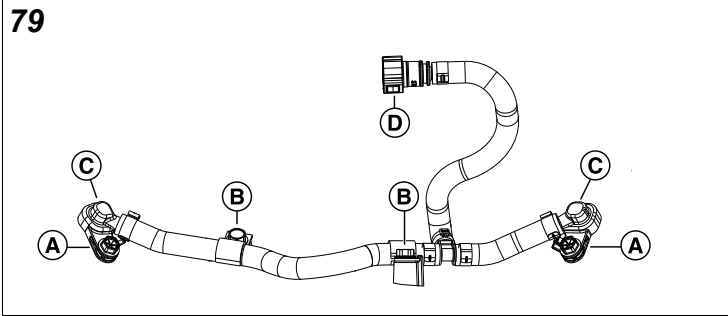


11. Remove the stepper motor and bracket (if equipped). Discard old gasket.
12. Remove mixer assembly from intake manifold. Discard old gasket.
13. On **vertically-mounted** mixers, remove the insulator spacer from the intake manifold. Discard old gasket.

- On **horizontally-mounted** mixers, remove the 3 fasteners that secure the intake manifold elbow to the intake manifold. Remove the elbow and insulator spacer from the manifold. Discard old gasket.

Fuel Rail and Fuel Injectors - EFI

- Pull out green secondary lock and press tab to disconnect fuel injector connectors.
- Remove the 2 fasteners to release fuel injector cap flanges from intake manifold (A, Figure 79).

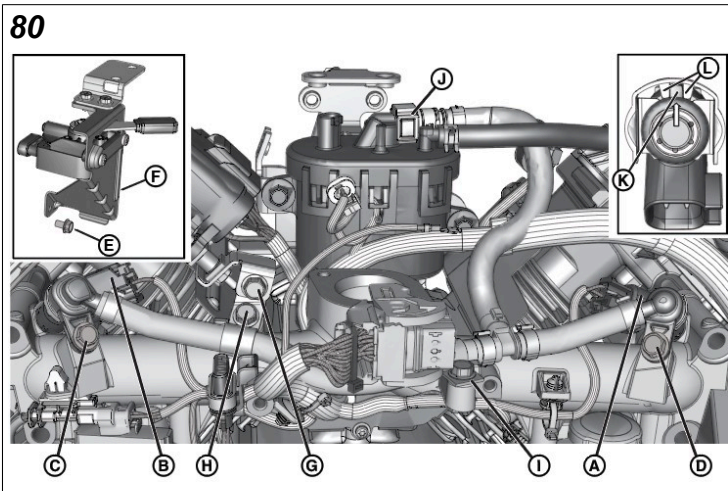


- Remove the 2 fasteners to release fuel rail clamps from intake manifold (B).
- Remove retaining clips to release fuel injector caps (C) from fuel injectors. Note orientation of the retaining clips prior to removal.
- Remove fuel injectors from intake manifold.
- Squeeze 2 tabs on quick disconnect fitting (D) to release fuel rail from fuel pump module.

NOTE: Wrap shop towel around fitting to catch any fuel leakage.

Fuel Rail and Fuel Injectors - EFI-ETC

- Disconnect cylinder 1 and cylinder 2 fuel injector connectors (A - B, Figure 80). Pull out white secondary lock, and then press and hold tab before pulling apart connector halves.



- Remove 2 fasteners (C - D) to release fuel injector cap flanges from intake manifold.

- Remove retaining clips and then remove fuel injector caps from fuel injectors.
- Remove fuel injectors from intake manifold bores.
- To remove fuel rail, proceed as follows:

A. Cylinder 2 (Oil Filter) Side:

- If equipped, remove fastener (E) to release throttle lever bracket (F) from intake manifold boss. Disconnect throttle lever module connector to remove assembly.
- Remove fastener (G) to release fuse/relay block bracket from fuel rail hose clamp.
- Rotate fuse/relay block bracket outward.
- Remove fastener (H) to release hose clamp from intake manifold boss.
- Remove fuel rail hose from clamp.

B. Cylinder 1 (Starter Motor) Side:

- Remove hex flange screw (I) to release hose clamp from intake manifold boss.
- Remove fuel rail hose from clamp.
- Squeeze two tabs on quick disconnect fitting (J) to release fuel rail from fuel pump module fitting.

NOTE: Wrap shop towel around fitting to catch any fuel leakage.

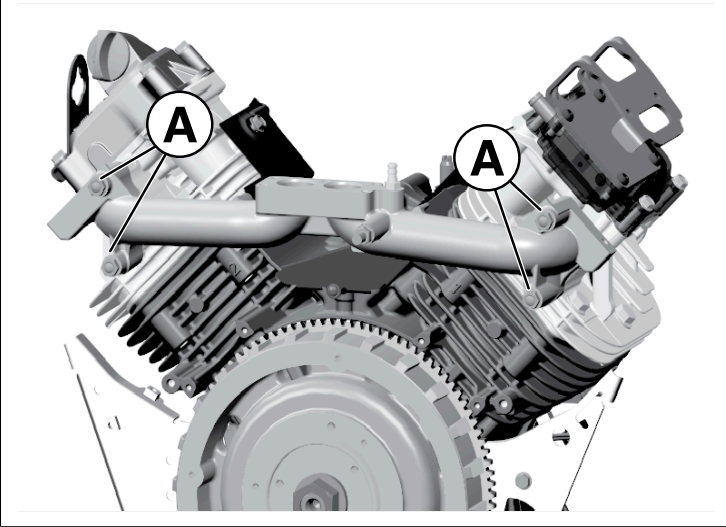
T-MAP Sensor - EFI

- Pull out the red secondary lock and press to disconnect the T-MAP sensor electrical connector.
- Remove the fastener to release sensor flange from intake manifold.
- Remove the sensor from the intake manifold and set aside.

Intake Manifold

1. Remove the 4 intake manifold fasteners (A, Figure 81).

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2. Remove the intake manifold from the cylinder heads.
3. Remove and discard the intake manifold gaskets.
4. Clean the intake manifold and cylinder head mating surfaces of all old gasket material. The mating surfaces need to be clean, dry and free of all contamination and gasket material.

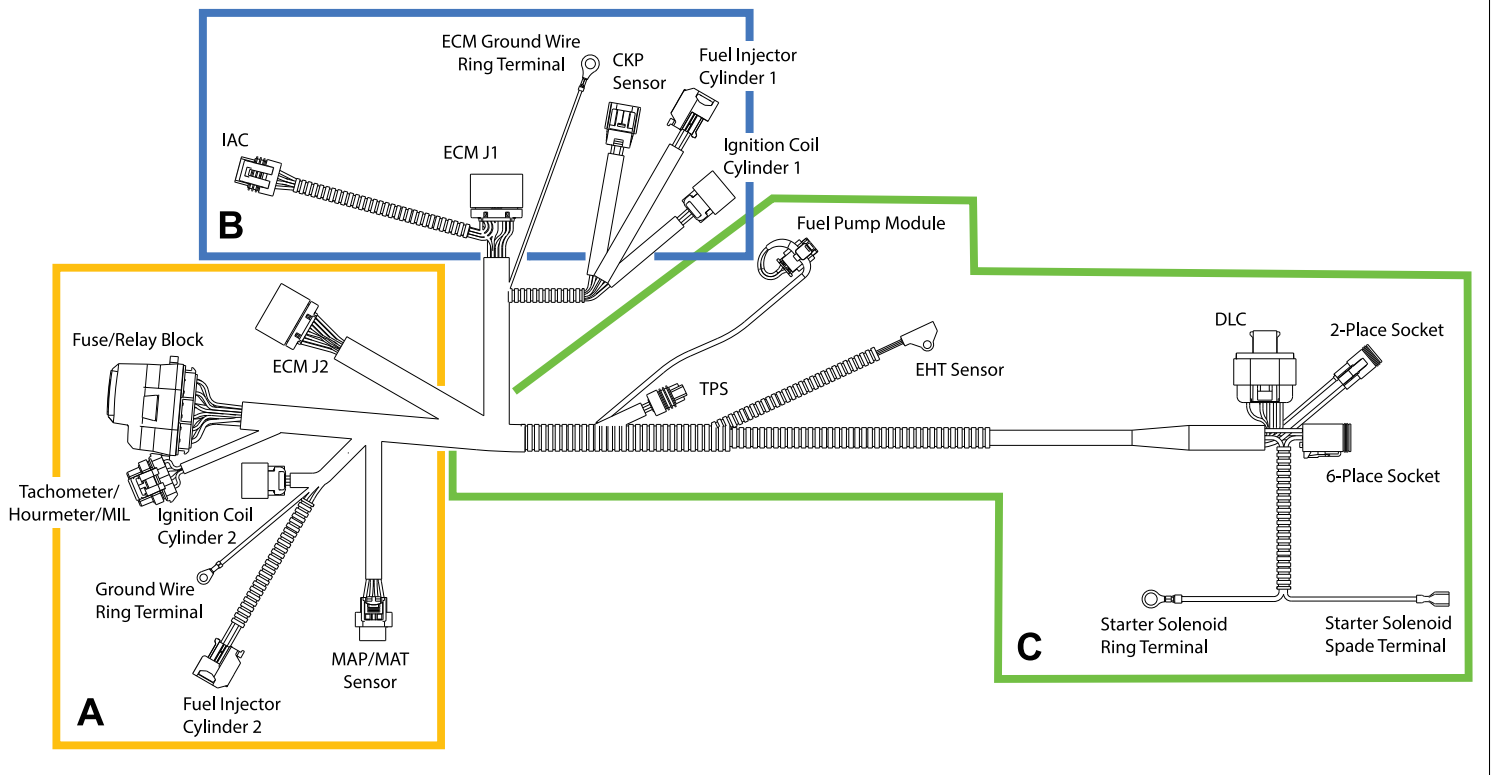
Wire Harness - EFI

The instructions for the removal of the wiring harness for EFI engines can be used as a stand-alone instruction on an assembled engine OR in conjunction with the disassembly process of an engine.

If you are removing the engine wiring harness as a part of the disassembly process, reserve the instructions to disconnect the harness from various components until those components are to be removed on the engine.

1. On cylinder 2 side of engine, see **A**, Figure 82 and proceed as follows:
 1. Remove fastener to release fuse block cover from ECM/fuse block bracket.
 2. Disconnect MAP/MAT sensor connector.
 3. Disconnect fuel injector connector.
 4. Disconnect ignition coil connector.
 5. Remove fastener to release ground wire ring terminal from cylinder boss.
 6. Disconnect ECM J2 connector.
2. On cylinder 1 side of engine, see **B**, Figure 82 and proceed as follows:
 1. Disconnect ECM J1 connector.
 2. Remove fastener to release ECM ground wire ring terminal from ECM/fuse block bracket.
 3. Disconnect fuel injector connector.
 4. Disconnect ignition coil connector.
 5. Remove fastener to release EHT sensor bracket from cylinder 1.
 6. Disconnect 2- and 6-place (or single 8-place) engine to chassis connectors.
 5. Disconnect starter solenoid ring and spade terminals.
3. See **C** of Figure 82 and proceed as follows:
 1. Disconnect TPS connector.
 2. Disconnect fuel pump module connector.
 3. Remove fastener to release EHT sensor bracket from cylinder 1.
 4. Disconnect 2- and 6-place (or single 8-place) engine to chassis connectors.
 5. Disconnect starter solenoid ring and spade terminals.
4. Remove the 2 fasteners to remove air block mounting plate. See *Air Block Plate, Valley Air Guides, Speed Control Bracket* in this section.
5. Feed wire harness conduit and connectors up through air block mounting plate opening.
6. Cut two cable straps around intake manifold between air block mounting plate and inside ignition coil mounting bosses.
7. Remove EFI wire harness from engine.

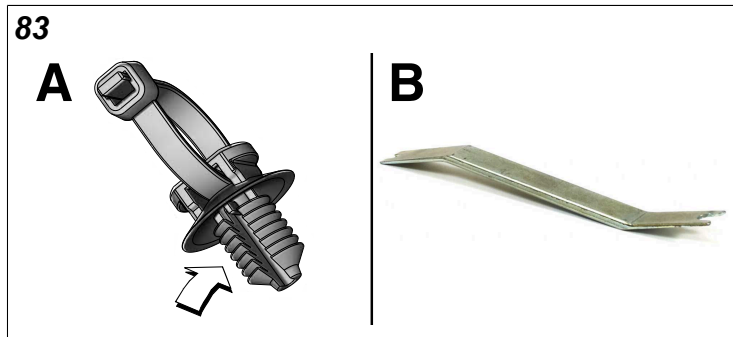
82



Wire Harness - EFI-ETC

The instructions for the removal of the wiring harness for EFI-ETC engines can be used as a stand-alone instruction for an assembled engine OR in conjunction with the disassembly process of an engine.

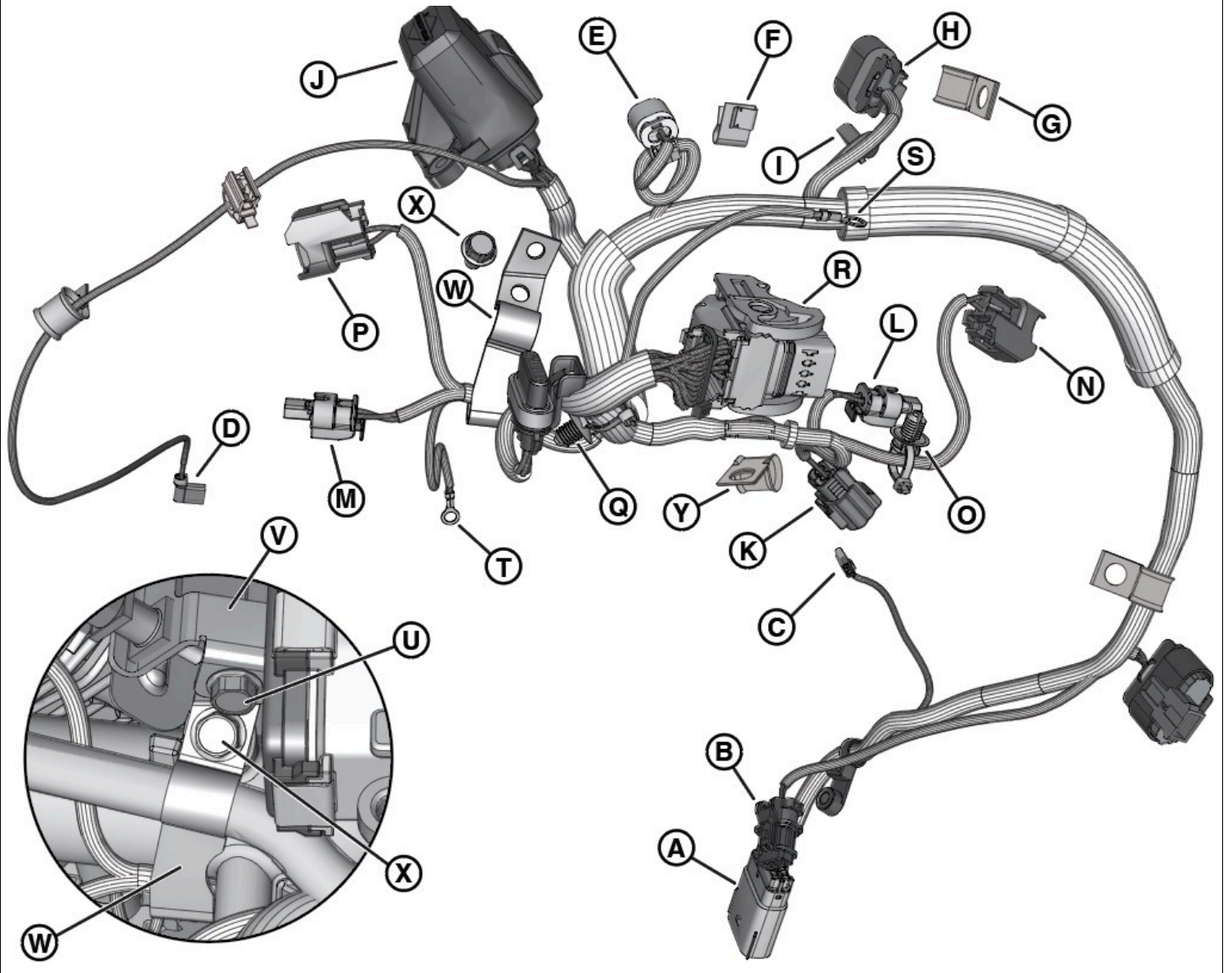
If you are removing the engine wiring harness as a part of the disassembly process, reserve the instructions to disconnect the harness from various components until those components are to be removed on the engine.

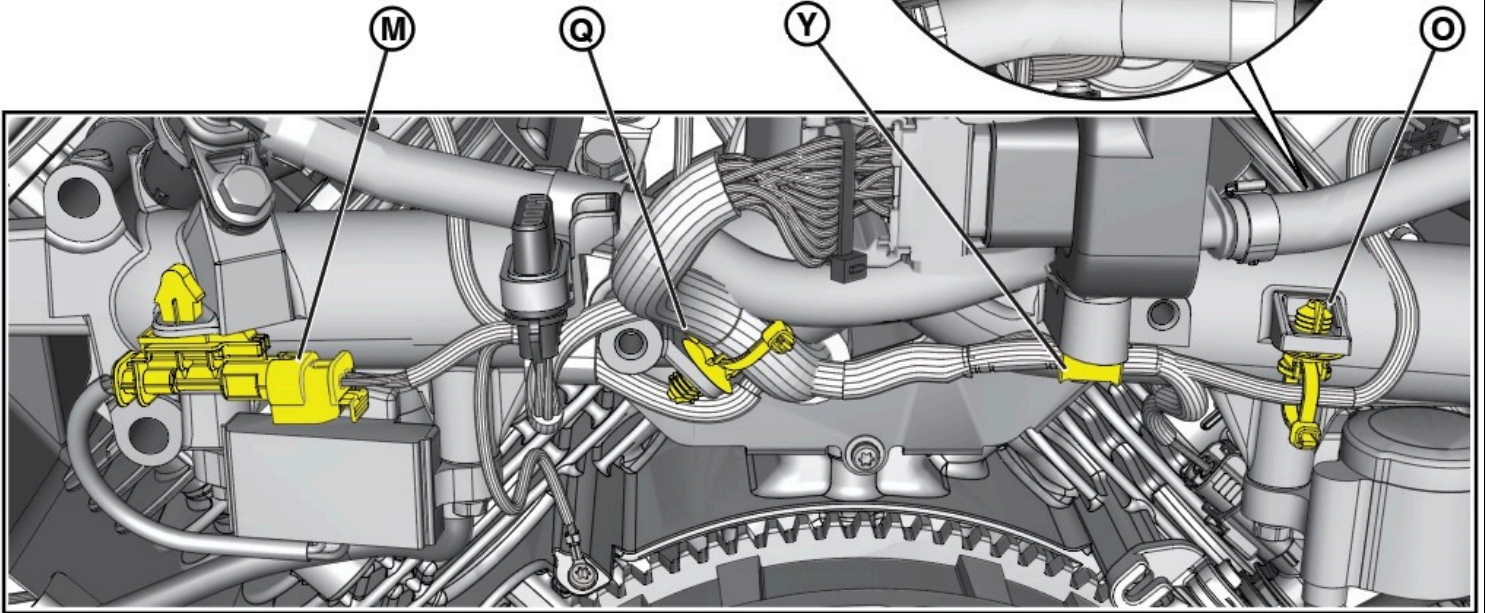
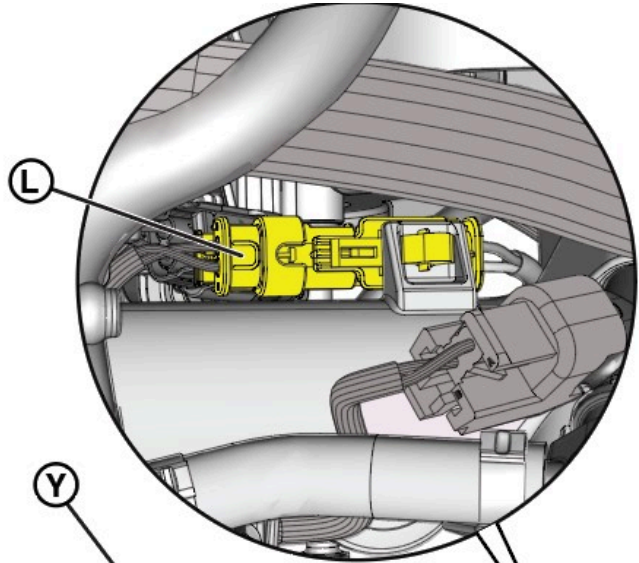
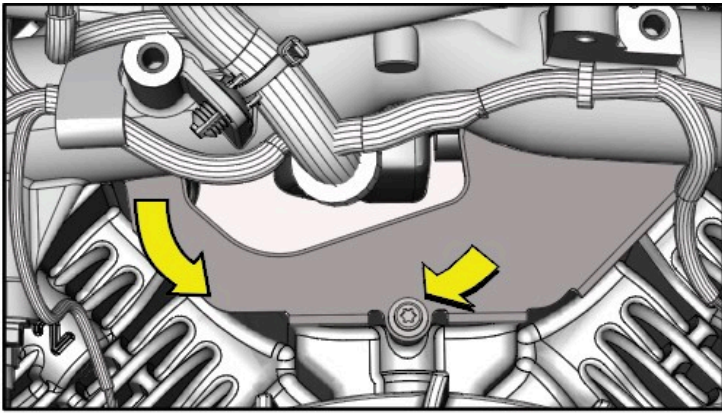


NOTE: The anchor on the fir tree style clip (A, Figure 83) resembles an upside down fir tree. Due to the rib configuration, the anchor is a very tight fit. To avoid damage to the clips and/or engine components, use the Briggs & Stratton Fuel Line Removal Tool (B) to gently pry the clip from the anchor hole. If the clip is broken during removal, be sure to remove all plastic debris from the engine.

1. On starter motor side of engine, press tab and disconnect main vehicle connector (A, Figure 84).
2. Disconnect electric lift fuel pump connector (B).
3. Remove elbow spade socket terminal (C) from starter solenoid spade contact.
4. Remove elbow spade socket terminal (D) from oil pressure switch spade contact. Remove wire harness retention clips, if still attached.
5. Disconnect fuel pump module connector (E). Pull out gray secondary lock, and then press and hold tab before pulling apart connector halves.
6. Remove O₂ sensor conduit from clip (F) at top of fuel pump module bracket support.
7. Remove hex flange screw to release wire harness clip (G) capturing O₂ sensor and EHT sensor conduit from fuel pump module bracket support. Remove clip from wire harness.
8. Disconnect O₂ sensor connector (H). Press tab to remove grey secondary lock, and then press black tab to separate connector halves.
9. Remove fastener to release EHT sensor (I) from cylinder head.
10. Disconnect fuse/relay block (J) from cover.
11. Disconnect CKP sensor connector (K).

12. Disconnect cylinder 1 ignition coil connector (L, Figure 85) after removing anchor of rosebud style clip from boss at rear of intake manifold. Pull out red secondary lock, and then press and hold tab before pulling apart connector halves. Remove 2 fasteners to release ignition coil from intake manifold bosses, if necessary.
13. Disconnect cylinder 2 ignition coil connector (M, Figure 85) at front of intake manifold. Pull out red secondary lock, and press and hold tab before pulling apart connector halves.
14. Disconnect cylinder 1 fuel injector connector (N, Figure 84) after removing anchor of fir tree style clip (O, Figure 85) from boss at front of intake manifold. Pull out white secondary lock, and press and hold tab before pulling apart connector halves. Remove fuel injector cap fastener if connector is caught beneath fuel rail.
15. Disconnect cylinder 2 fuel injector connector (P, Figure 84). Pull out white secondary lock, and press and hold tab before pulling apart connector. Remove fuel injector cap fastener if connector is caught beneath fuel rail.
16. Remove anchor of fir tree style clip (Q in Figure 85) to release wire harness from intake manifold boss.
17. Disconnect ECM connector (R).
18. Remove fastener to release ECM ground wire ring terminal (S) from throttle body.
19. Remove fastener to release engine ground wire ring terminal (T) from crankcase boss.
20. Proceed as follows:
 - A. Cylinder 2 (Oil Filter) Side:
 - Remove fastener (U) to release fuse/relay block bracket (V) from double-sided clamp (W) at top of intake manifold.
 - Rotate fuse/relay block bracket outward.
 - Remove fastener (X) to release clamp from intake manifold boss.
 - Remove wire harness from clamp.
 - B. Cylinder 1 (Starter Motor) Side:
 - Remove fastener to release wire harness clip (Y, Figure 85) from intake manifold boss.
21. Remove the 3 fasteners to release fuel pump module bracket from fuel pump module bracket support. Move assembly up and out of the way.
22. See inset of Figure 85. Remove fastener to release air block plate from crankcase. Rotate plate in a counter-clockwise direction to enlarge opening for harness removal.
23. Feed branches of wire harness down and then out through opening next to air block plate.





Wire Harness - Carbureted and Gaseous

The instructions for the removal of the wiring harness for carbureted and gaseous engines can be used as a stand-alone instruction on an assembled engine OR in conjunction with the disassembly process of an engine.

If you are removing the engine wiring harness as a part of the disassembly process, reserve the instructions to disconnect the harness from various components until those components are to be removed on the engine.

1. Disconnect the engine harness to equipment connector (**A**, Figure 86) if not already completed.
2. Disconnect the starter solenoid spade connector (**B**) from the starter solenoid.
3. Disconnect the anti-afterfire solenoid connector, if equipped, (**D**) from the solenoid.
4. Remove the fastener that secures the anti-afterfire ground ring terminal AND harness ground (**C** and **E**) from the engine and move ground wires aside.

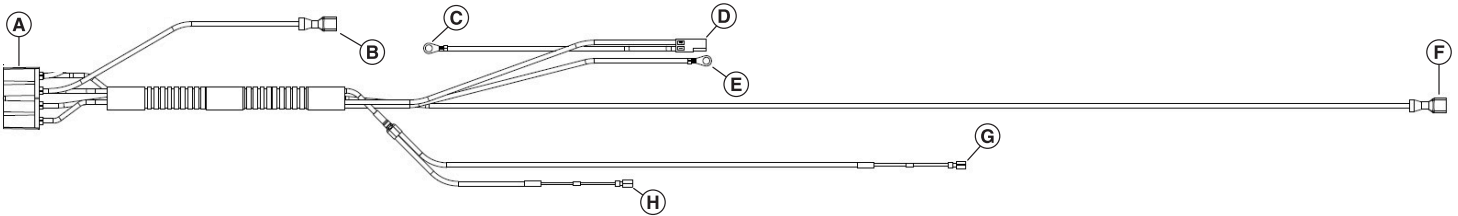
5. Disconnect the ignition armature spade connectors (**G-H**) from the armatures.

NOTE: The wiring for the ignition armatures, oil pressure switch, and grounds may be secured to the intake manifold with tie wraps. Cut the tie wrap to release the wiring from the intake manifold.

NOTE: If removing the engine wire harness on a fully assembled engine, it is necessary to remove the engine covers blower housing to access component connectors. Refer to *Engine Covers* and *Blower Housing* in this section for removal instructions.

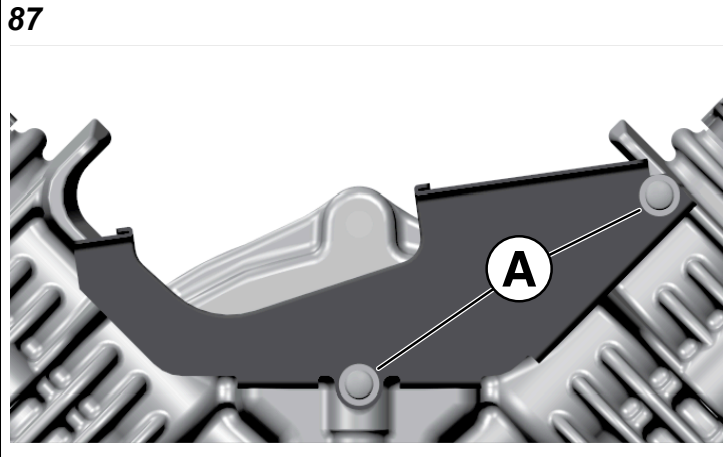
6. Disconnect the oil pressure switch spade connector (**F**) from the switch.
7. Remove the engine wire harness from the engine. Make sure to note wire routing and any additional wire clamps to ensure proper installation.

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Air Block Plate, Valley Air Guides, Speed Control Bracket

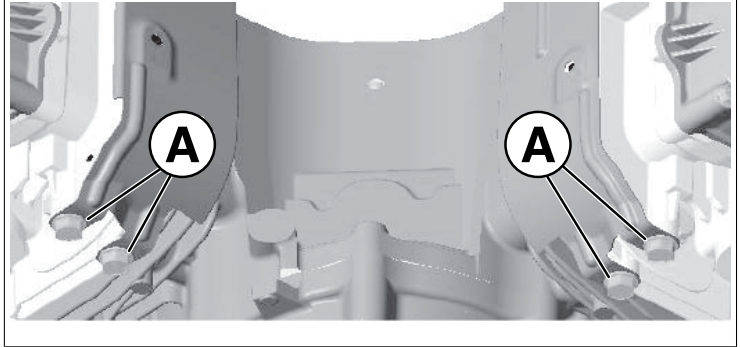
1. Remove the 2 valley air block plate mounting fasteners (A, Figure 87).



2. Remove the valley air block plate from the engine and set aside.

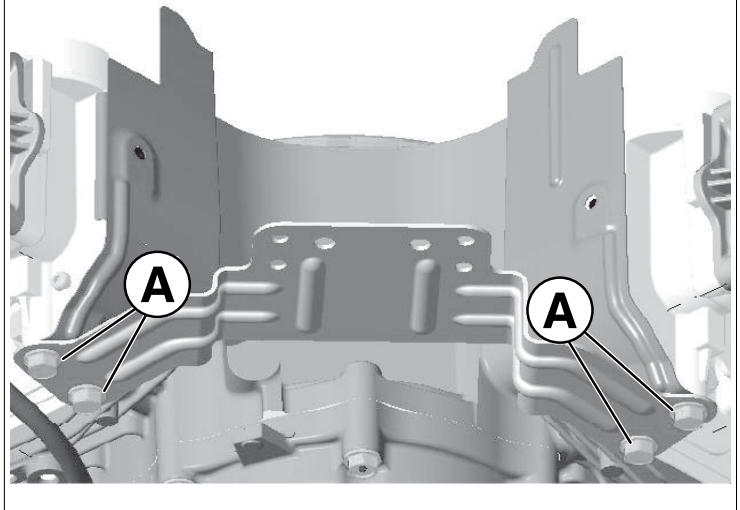
3. Remove the 4 valley air guide fasteners (A, Figure 88).

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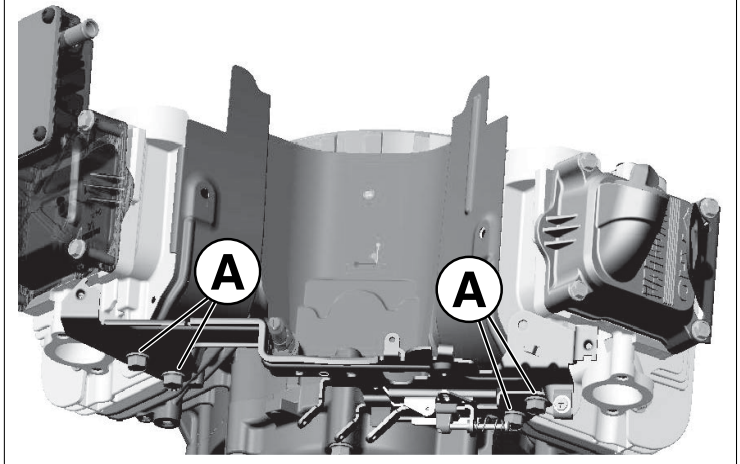


NOTE: Your engine may be equipped with an air filter support bracket or a speed control bracket. These brackets utilize the valley air guide fasteners to attach to the engine. See Figure 89 for engines equipped with the low-profile air cleaner support bracket, and see Figure 90 for engines equipped with the speed control bracket.

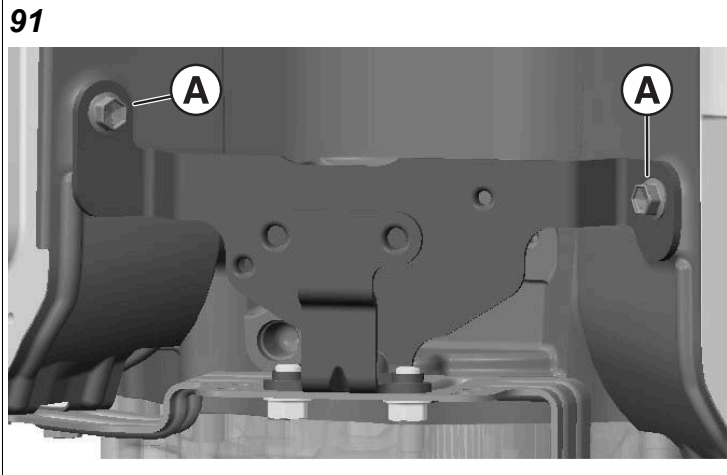
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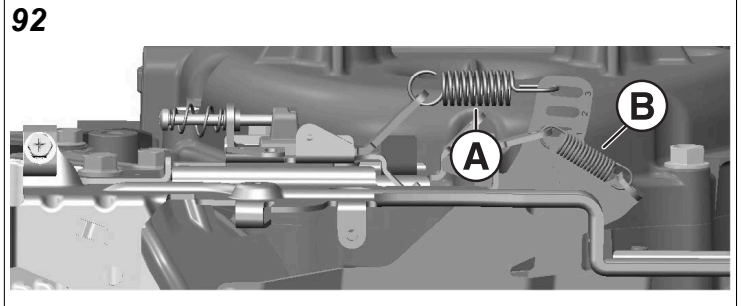
4. If equipped, remove the 2 fasteners that secure the fuel module support bracket to the engine (**A**, Figure 91).



NOTE: Depending on your engine's model and trim, the valley support bracket may be used for the fuel pump module or air cleaner. Several mounting options exist and may require the removal of additional fasteners connecting the valley support bracket to the speed control bracket.

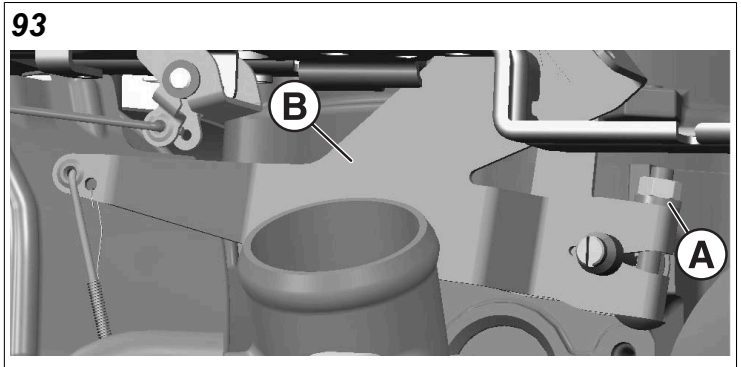
Governor Arm Bracket

1. Release the high-speed (**A**, Figure 92) and low-speed (**B**) governor arm springs.



NOTE: Make a note of the governor arm spring positions for proper reassembly. Check springs for fatigue, and replace if necessary.

2. Loosen the governor arm bracket pinch bolt (**A**, Figure 93).



3. Remove the bracket (**B**) from the governor arm by pulling the bracket straight up.

SECTION 5 - DISASSEMBLE ENGINE

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TOP END DISASSEMBLY

Preliminary Instructions

Prior to starting any repair or maintenance operation. Make sure you are familiar with ALL safety warnings and procedures as outlined in *SECTION 1 - SAFETY AND GENERAL INFORMATION - Safety Information*.

ALWAYS wear safety glasses and gloves while performing any maintenance and repair operation.

Top End Disassembly

1. See *SECTION 4 - REMOVE EXTERNAL ASSEMBLIES* for component removal necessary to access the engine cylinder heads.
2. Thoroughly clean exterior surfaces of engine prior to disassembly. Proceed as follows:

NOTE: Dirt caked on cooling fins and other areas can fall into cylinder bore or stick to subassemblies as parts are removed. Abrasive particles can damage machined surfaces and plug oil passageways.

- A. Remove all loose debris by hand.
 - B. Remove dust and dirt with a soft bristle brush and a portable hand held vacuum.
 - C. Gently scrape away stubborn accumulations of dirt and other deposits using a plastic putty knife or stiff bristle brush.
 - D. Apply a light solvent to bristle brush to loosen and remove grit and oily residue, if necessary.
3. Thoroughly clean area around spark plugs to keep dirt and debris out of combustion chambers.
 4. Remove spark plug (**A**, Figure 94) from cylinder head using a 5/8 inch spark plug wrench.
 5. Remove the 4 fasteners (**B**) that secure the valve cover (**C**) and lifting bracket (**D**) to the cylinder head.

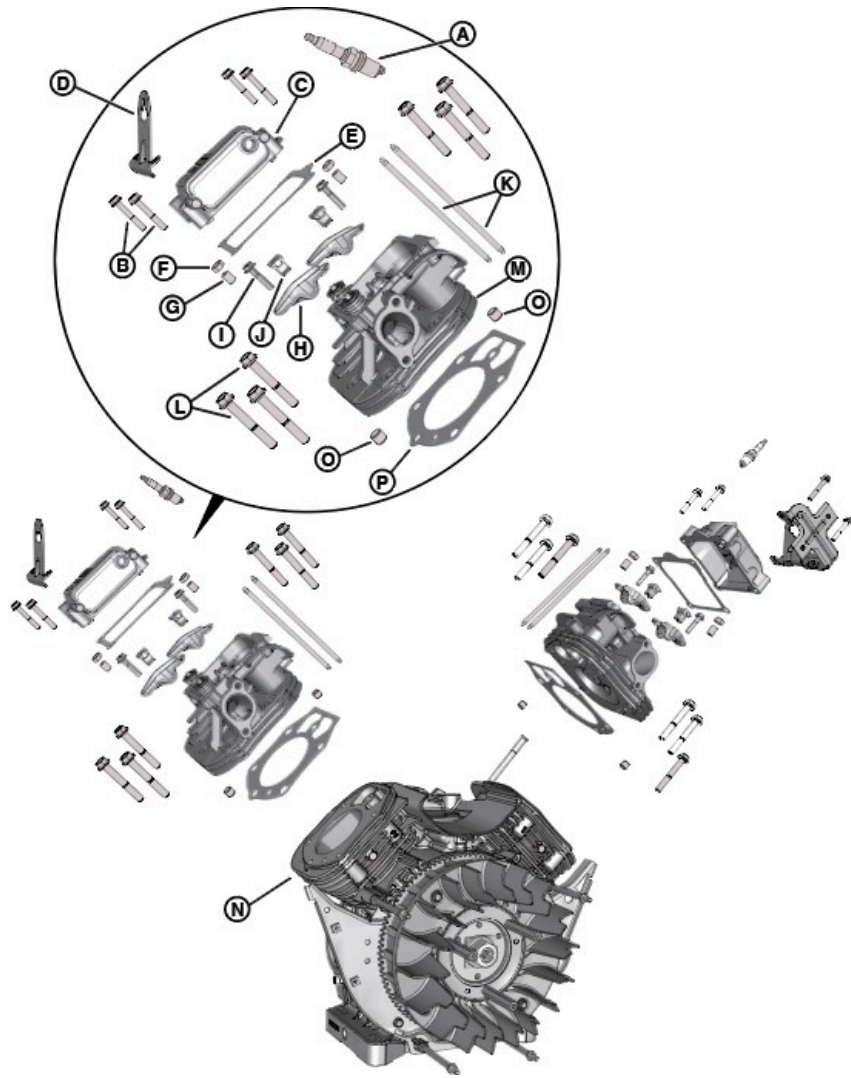
NOTE: Depending on your engine model trim and configuration, additional brackets may be attached to the cylinder head. For example, on carbureted engines, the fuel pump mounting bracket is attached to the cylinder head with the valve cover fasteners. Take note of any additional mounting brackets and their orientation prior to disassembly.

6. Remove the valve cover from the cylinder head and discard the old valve cover gasket (**E**).

7. Move piston of first cylinder to Top Dead Center (TDC) of the compression stroke. Proceed as follows:

NOTE: Disassembly with the valve train loaded can result in bent push rods.

- A. While rotating flywheel end of crankshaft by hand in the direction of engine rotation, watch the rocker arms to determine the action of the valves. After the exhaust valve closes, the intake valve begins to open.
 - B. When the intake valve closes (so that both valves are closed with the rocker arms loose), insert a wooden dowel through the spark plug hole until seated at the top of the piston.
 - C. Rotate engine in the same direction until the piston pushes the wooden dowel to its highest point. This is TDC of the compression stroke.
8. Loosen hex lock nuts (**F**) and remove the T-40 TORX adjuster screws (**G**) from rocker arms (**H**). Remove hex flange screws (**I**), fulcrums (**J**), and rocker arms from cylinder head.
 9. Remove the intake and exhaust push rods (**K**).
 10. Repeat steps 4-9 on the opposite cylinder.
 11. Remove 6 cylinder head bolts (**L**) to release cylinder head (**M**) from crankcase (**N**).
 12. Remove cylinder head from 2 locating pins (**O**) cylinder deck.
 13. Remove and discard the old cylinder head gasket (**P**).
 14. Remove locating pins from cylinder deck and set aside. Make sure to note their location to ensure they are reinstalled in the correct position.
 15. See *SECTION 6 - SERVICE ENGINE SUBASSEMBLIES, CYLINDER HEAD*.

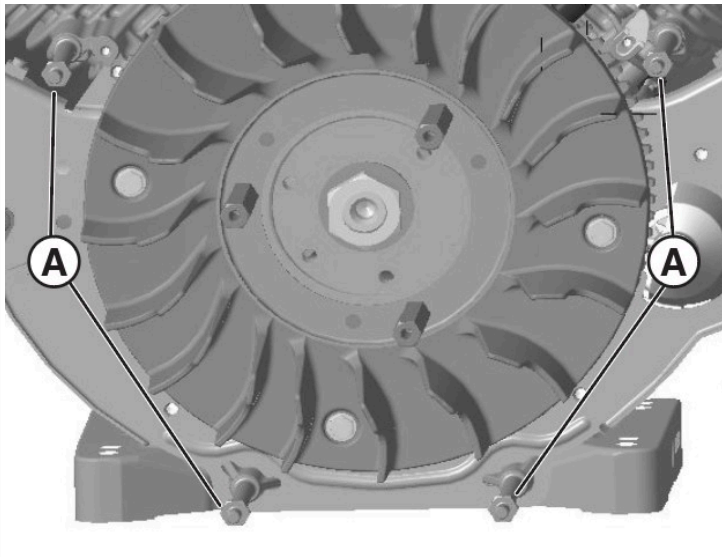


BOTTOM END DISASSEMBLY

Flywheel Fan and Flywheel

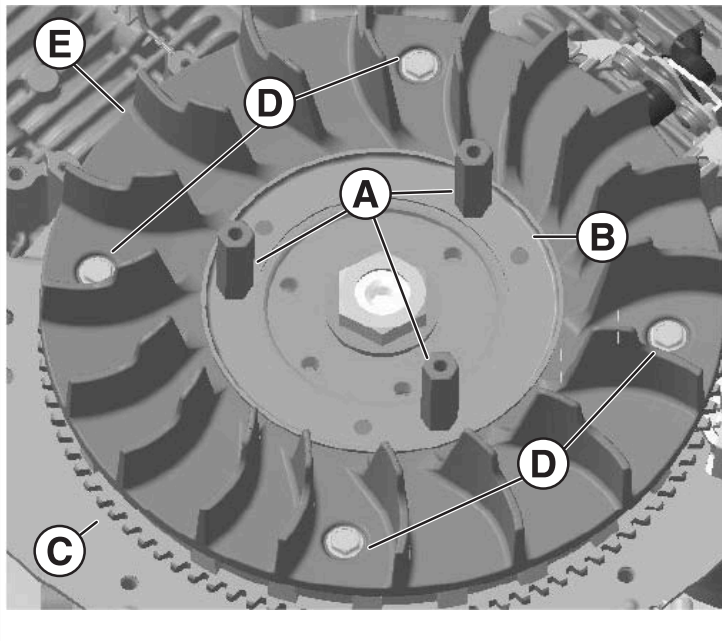
1. See *SECTION 4 - REMOVE EXTERNAL ASSEMBLIES* for information on disassembly steps necessary prior to flywheel fan and flywheel removal.
2. Remove four blower housing mounting posts (A, Figure 95) from crankcase.

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3. Remove the 3 studs (A, Figure 96) to release fan ring (B) from flywheel (C).

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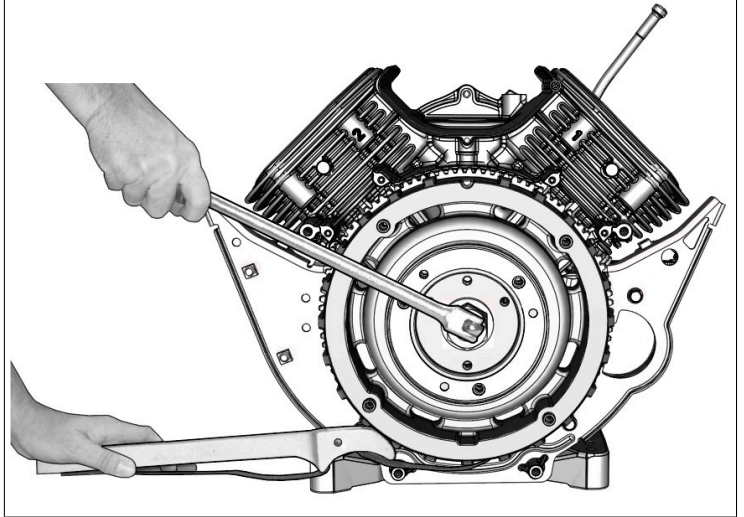


4. Remove the 4 four fasteners (D) to release fan (E) from flywheel.

5. Obtain the Strap Wrench (see *SECTION 3 - TROUBLESHOOTING - Special Tool List*), correct size socket for flywheel nut, and breaker bar. See Figure 97 and proceed as follows:

NOTE: DO NOT use an impact wrench to loosen the flywheel nut. Thread damage may occur.

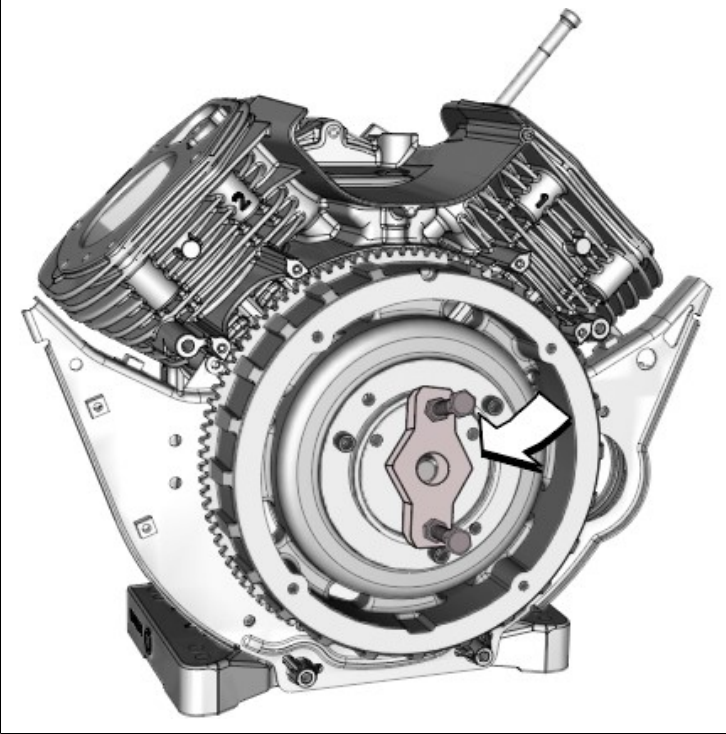
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- A. Fit loop of strap around flywheel and tighten until snug.
 - B. Pinch strap between heel of wrench and flywheel as shown.
 - C. Holding tool down by the handle, loosen flywheel nut using breaker bar and socket.
 - D. Remove strap wrench from flywheel.
6. Remove flywheel nut and flat washer from crankshaft.

7. Obtain Flywheel Puller (see *SECTION 3 - TROUBLESHOOTING - Special Tool List*), see Figure 98 and proceed as follows:

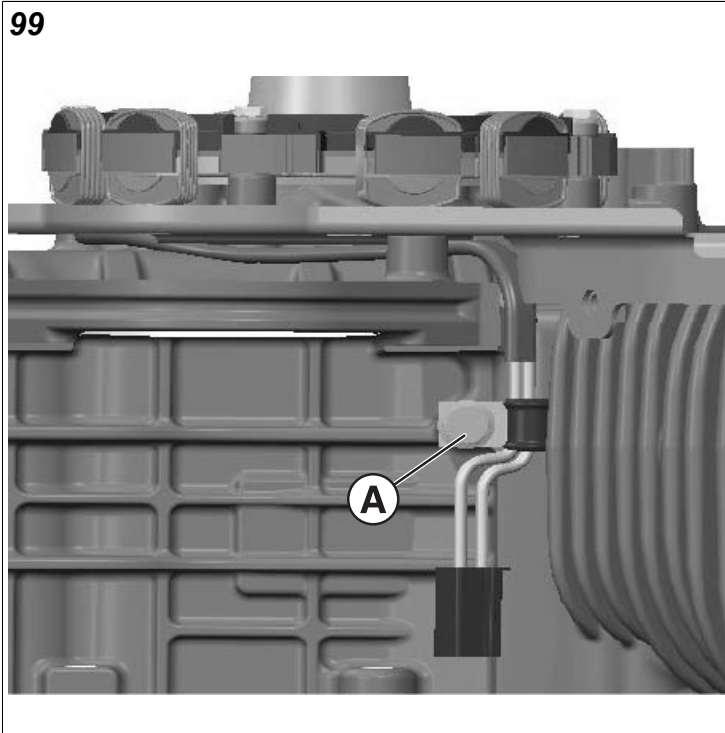
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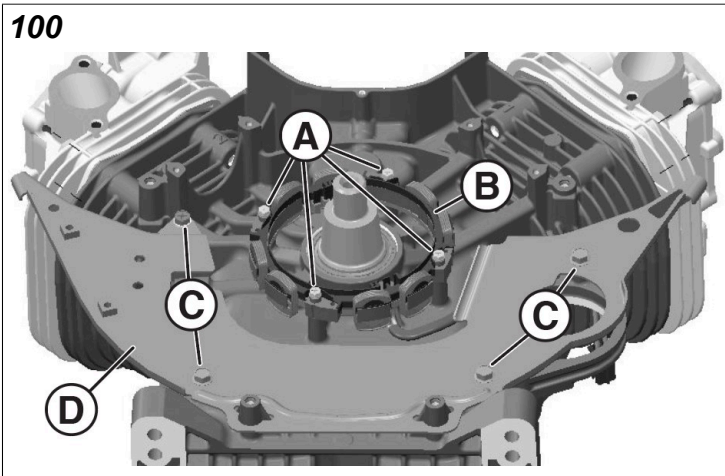
- A. Install flywheel nut until top is flush with end of crankshaft.
 - B. Run hex nut about half way down each of 2 puller screws.
 - C. Install puller screws into holes in puller.
 - D. Run remaining 2 hex nuts several threads down each puller screw.
 - E. Place center hole in puller over flywheel nut, and start puller screws into threaded holes in flywheel. Install puller screws into flywheel an equal number of turns until positive engagement is obtained.
 - F. Move top hex nuts down puller screws until firm contact is made with top of puller.
 - G. Move bottom hex nuts down puller screws until firm contact is made with flywheel.
 - H. Verify that tool is square, and not slanting or leaning.
 - I. Alternately turn each puller screw in small increments until flywheel is free.
 - J. Remove puller from flywheel.
8. Remove flywheel from crankshaft and set aside.
9. Remove the key from keyway on crankshaft taper.

Alternator and Guard Plate

1. Remove the fastener (A, Figure 99) to release the alternator wire clamp from crankcase.



2. Remove the 4 fasteners and washers (A, Figure 100) to release the alternator (B) from crankcase bosses.

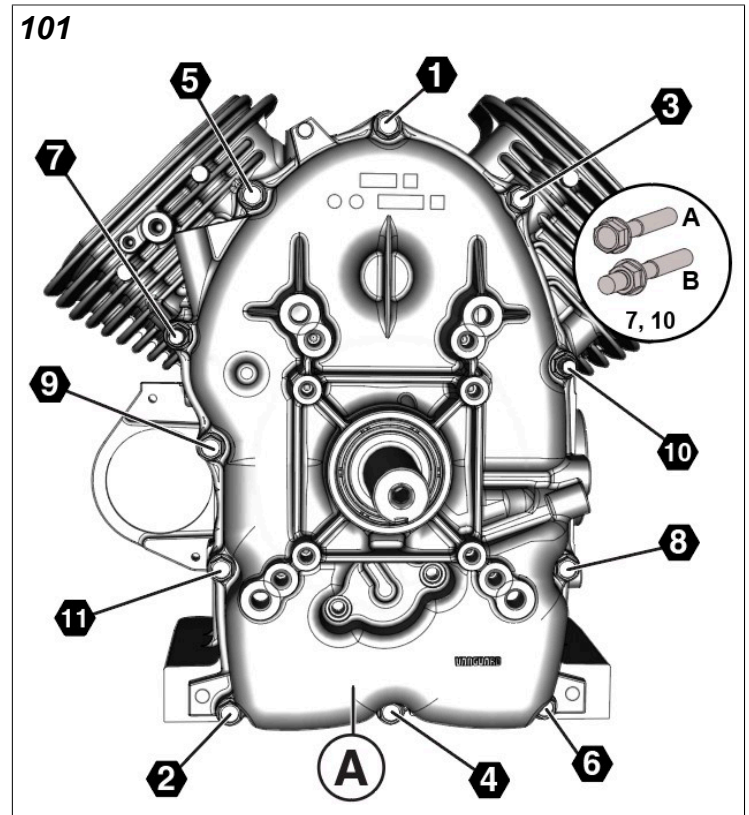


NOTE: The image in Figure 100 depicts the 20 Amp alternator assembly. The 20/50 Amp alternator appears visually different to the 20 Amp alternator, however, the removal process is identical.

3. Remove the alternator from the engine and set aside. Take care to avoid damage to the alternator stator wiring.
4. Remove the 4 fasteners (C) to release the guard plate (D) from crankcase.
5. Remove the guard plate from the engine and set aside.

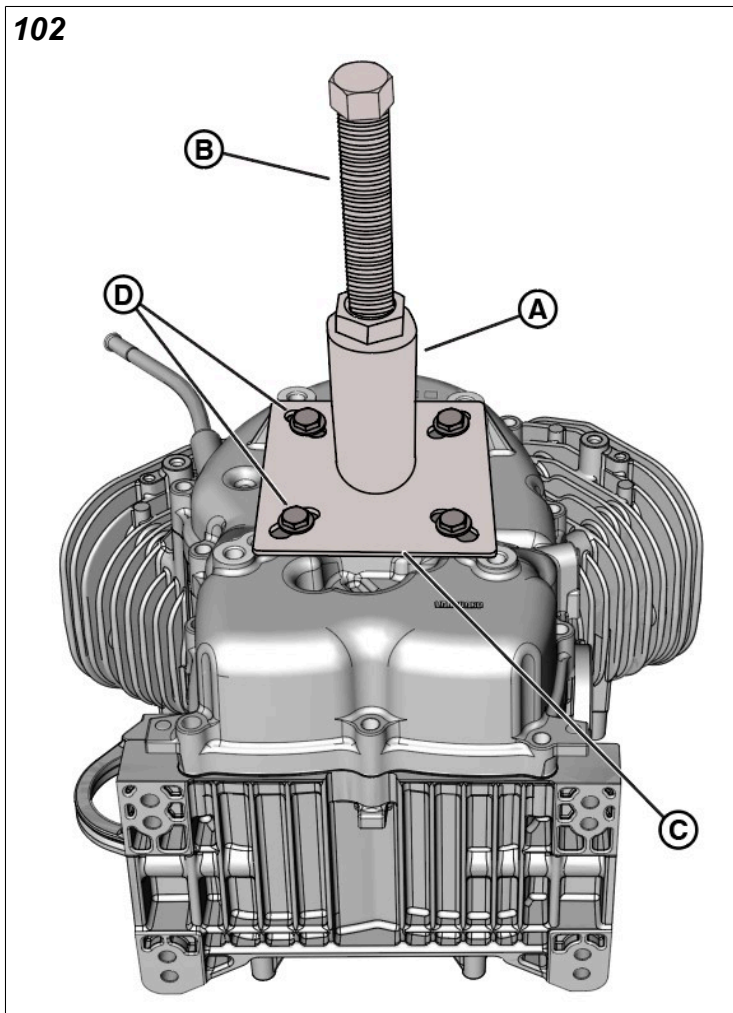
Bottom End Disassembly

1. Obtain a Crankcase Cover Puller, and proceed as follows:
2. Remove 11 fasteners (1 - 11, Figure 101) from crankcase cover (A).



- Place tube **A**, Figure 102) of puller over crankshaft seating end of forcing screw (**B**) at end of crankshaft.

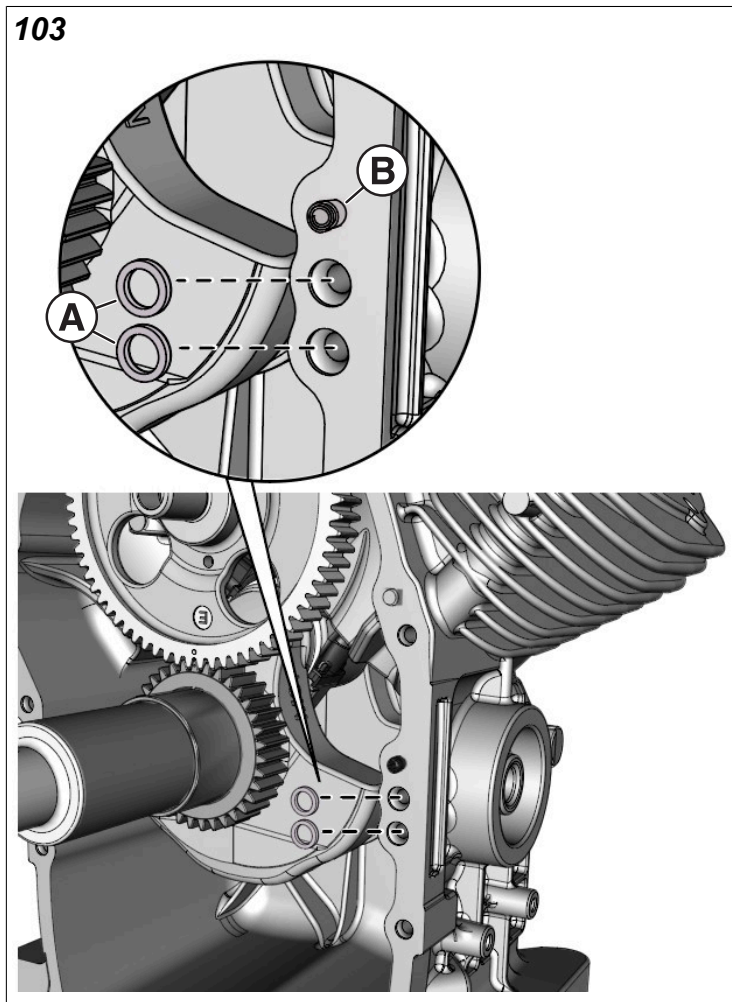
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- Back up forcing screw as necessary, so that base (**C**) seats flat against crankcase cover.
- Rotate base to align slots with 4 threaded holes in crankcase cover.
- Install 4 screws with flat washers (**D**) to fasten base to cover, and alternately tighten in a crosswise pattern until snug.
- Rotate forcing screw in a clockwise direction until cover is free. Remove cover from engine block and set aside.
- Remove screws to release puller tool from cover.

- Remove the 2 o-rings (**A**, Figure 103) from crankcase flange. Discard the old o-rings.

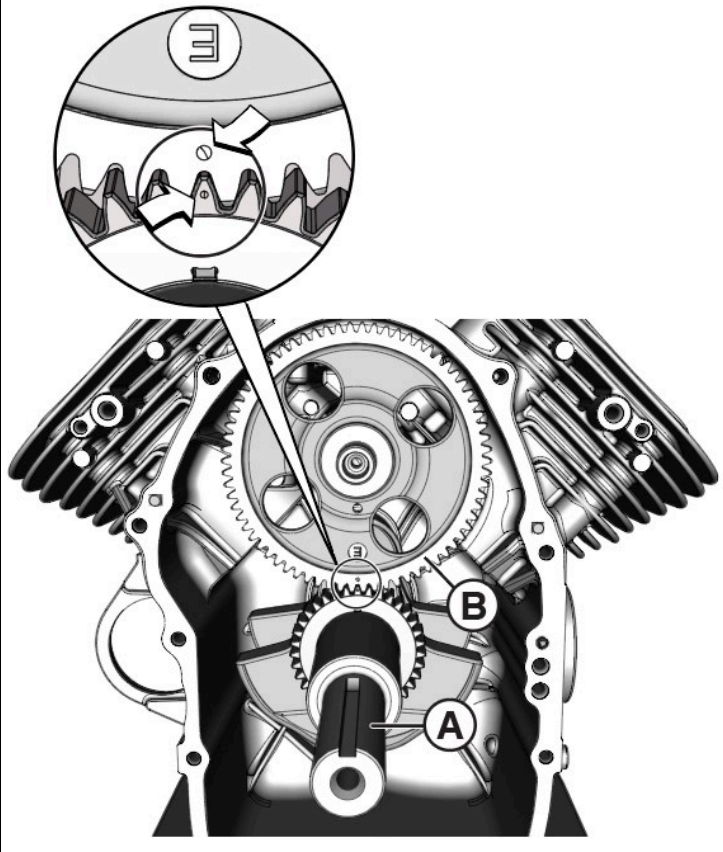
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- Remove locating pins (**B**) from crankcase flange and set aside.

11. Rotate crankshaft (**A**, Figure 104) to align timing marks (see inset image) on crankshaft gear tooth and camshaft gear root.

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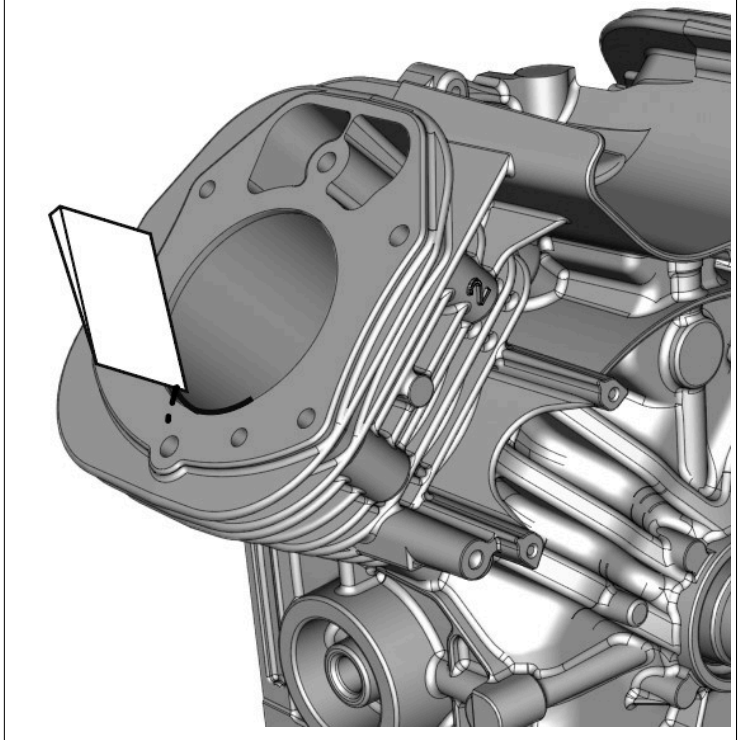


NOTE: Valve tappets are now clear of the camshaft lobes.

12. Remove camshaft (**B**) from bearing bore in crankcase.
13. Remove valve tappets from crankcase.
 - a. Tag each tappet as it is removed, so that it can be installed in its original location when the engine is assembled.
14. Rotate the crankshaft until piston is at the bottom of its stroke.

15. Use a **plastic** scraper to carefully remove carbon ridge at top of cylinder bore (**A**, Figure 105).

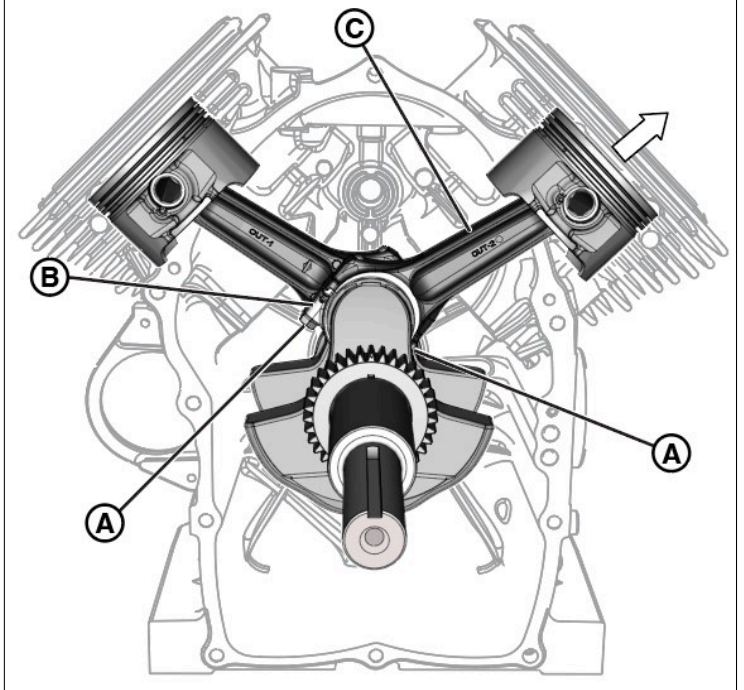
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NOTE: Failure to remove carbon ridge can result in piston ring breakage.

16. Rotate crankshaft as necessary to obtain best access to connecting rod cap screws.
17. Remove the 2 fasteners (**A**, Figure 106) to release connecting rod cap (**B**) from connecting rod (**C**).

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18. Remove connecting rod and piston assembly from cylinder bore.
19. Repeat steps 17-18 on opposite cylinder.
20. Remove crankshaft from crankcase.
21. See the following topics under *SECTION 6 - SERVICE ENGINE SUBASSEMBLIES*:

- *PISTON AND CONNECTING ROD*
- *FLYWHEEL, CRANKSHAFT AND CAMSHAFT*
- *CRANKCASE AND CRANKCASE COVER.*

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Preliminary Instructions

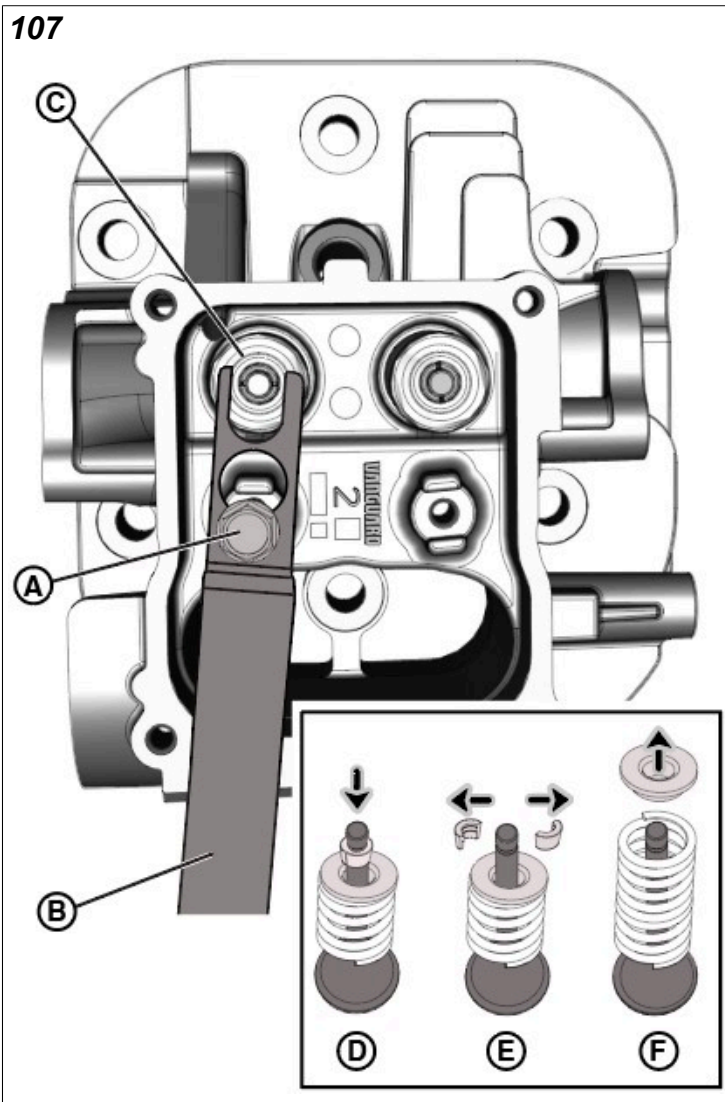
Prior to starting any repair or maintenance operation. Make sure you are familiar with ALL safety warnings and procedures as outlined in *SECTION 1 - SAFETY AND GENERAL INFORMATION - Safety Information*.

ALWAYS wear safety glasses and gloves while performing any maintenance and repair operation.

CYLINDER HEAD

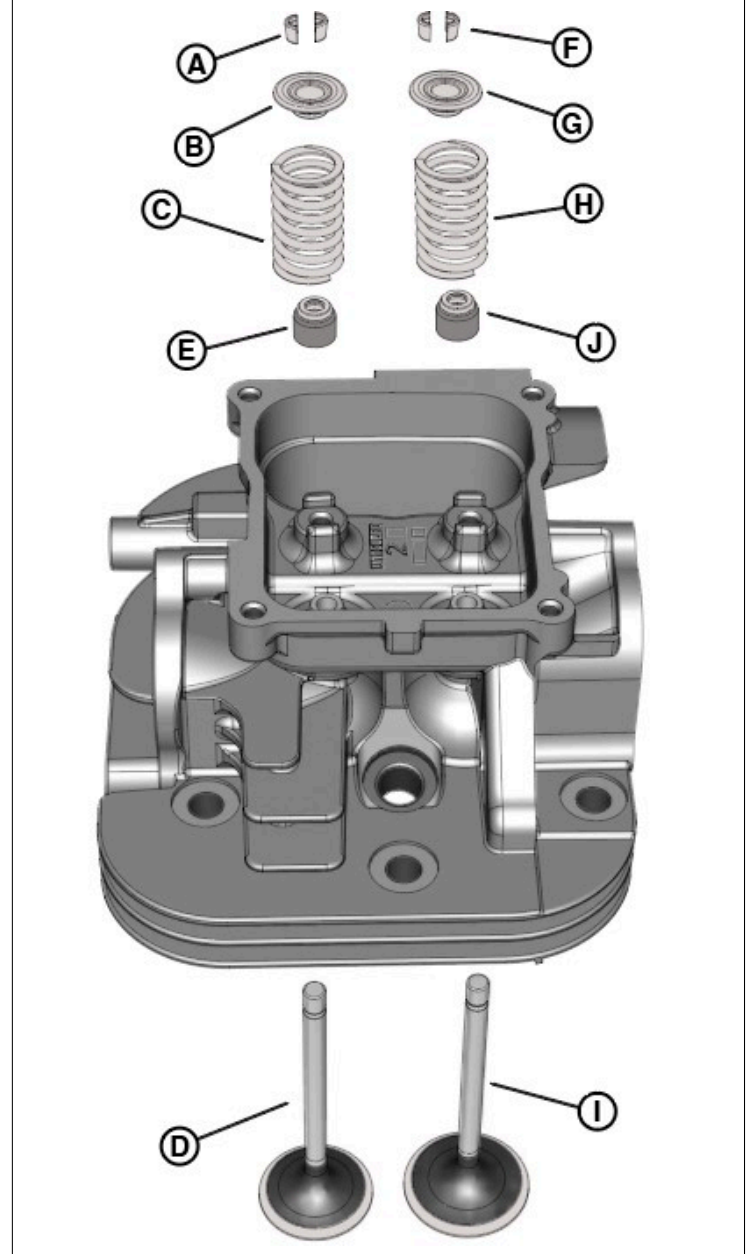
Disassembly

1. Pack shop towels into the combustion chamber and place cylinder head on bench with the combustion chamber side down.
2. Obtain valve spring compressor (see *SECTION 3 - TROUBLESHOOTING - Special Tools List*).
3. Starting with the exhaust valve, remove as follows:
4. Install fulcrum screw (A, Figure 107) and tighten until positive thread engagement is obtained.



5. Place tool (B) over head of fulcrum screw engaging small end of slot.
6. With prongs of tool on valve spring retainer (C), pivot tool to compress valve spring (D).
7. Using a magnet for best results, remove the tapered keepers (E) from the valve stem groove.
8. Release the valve spring compression.
9. Remove tool and fulcrum screw.
10. Remove the valve spring retainer and valve spring (F).
11. Remove valve (D, Figure 108) from valve guide.

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12. Remove and discard the valve stem seal (E).
13. Mark the bottom of the valve to identify it as the exhaust valve. Bag the valve, valve spring retainer, valve spring, and tapered keepers, so that all parts can be installed in their original locations at time of assembly.
14. Repeat steps 4 - 13 to remove intake valve.

15. Repeat steps 1 - 14 to remove valve assemblies from second cylinder head.

Cleaning

1. Remove all carbon deposits from combustion chamber and machined surfaces of cylinder heads. Exercise caution to avoid removing any metal material. For best results, use an air tool with a **worn** fine wire brush. Scraping may result in scratches or nicks.
2. To soften stubborn deposits, soak the cylinder heads in a suitable chemical solution or other carbon and gum dissolving agent. Repeat steps 1-2 as necessary.

NOTE: Do not use glass or sand to bead blast surfaces exposed to the engine oil. Bead blasting materials become lodged in the pores of the casting where they cannot be removed through ordinary cleaning methods. Only after the engine is put to use will heat expansion cause this material to be released, and the resulting oil contamination will accelerate wear and lead to engine failure.

3. Thoroughly clean the cylinder heads, valves, valve spring retainers, valve springs, tapered keepers, tappets, push rods, and rocker arms in a non-volatile cleaning solution or solvent. Follow up with a thorough wash in hot soapy water. Blow dry with low pressure compressed air.

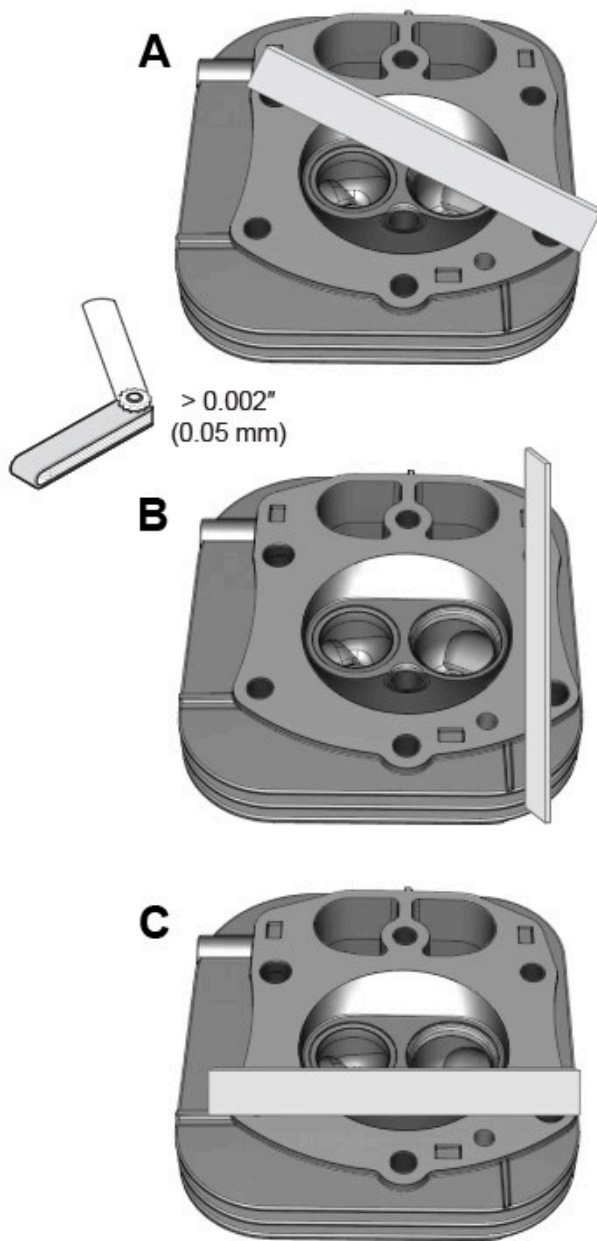
Inspection

Cylinder Head

1. Check for scratches and nicks on all gasket sealing surfaces.
2. Check condition of spark plug threads. If necessary, soften deposits with penetrating oil and clean out with a thread chaser.

3. Check the cylinder head to cylinder mating surface for warpage or distortion. Discard the cylinder head if any low spot is **0.002 inches** (0.05 mm) or more. Proceed as follows:

- A. With the combustion chamber side facing up, set a straightedge diagonally across the length of the cylinder head gasket surface (**A**, Figure 109).
- B. Slide a feeler gauge beneath the straightedge to check for warpage.
- C. Check the opposite diagonal to verify that the gasket surface is flat.
- D. Set a straightedge vertically across the length of the cylinder head gasket surface (**B**). Use feeler gauge to check for warpage. Repeat step on opposite side.
- E. Set a straightedge horizontally across the length of the cylinder head gasket surface (**C**). Use feeler gauge to check for warpage. Repeat step on opposite side.



- Repeat the 6 point check outlined under step 3 to check for warpage or distortion of the cylinder head to valve cover mating surfaces. Be sure to check both the cylinder head and valve cover. Discard the cylinder head or valve cover if any low spot is **0.002 inches** (0.05 mm) or more.
- Visually inspect the cylinder head for cracks or discoloration due to excessive heat. Replace cylinder head if either of these conditions are found.
- Verify that breather hole, and intake and exhaust ports are clean and open.

Valve Guide Inspection

- Inspect external surface of valve guides for cracks (particularly the combustion chamber side). Replace the cylinder head if cracks are found.

- To verify cleanliness, lightly hone bore using a suitable valve guide hone and then scrub with a valve guide cleaning brush to remove any dirt or debris.
- Measure the inside diameter using an inside ball micrometer or plug gauge. Replace the cylinder head if the measurement is **0.240 in** (6.106 mm) or more.

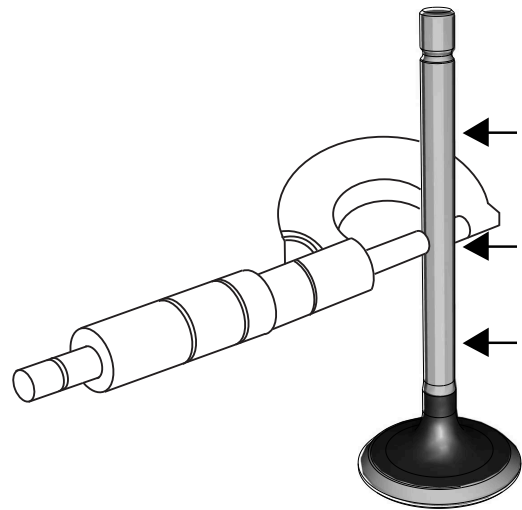
Valve Seat Inspection

- Inspect valve seats for cracking, chipping or burning. Replace cylinder head if any of these conditions are found or if either valve seat is loose.

Valves

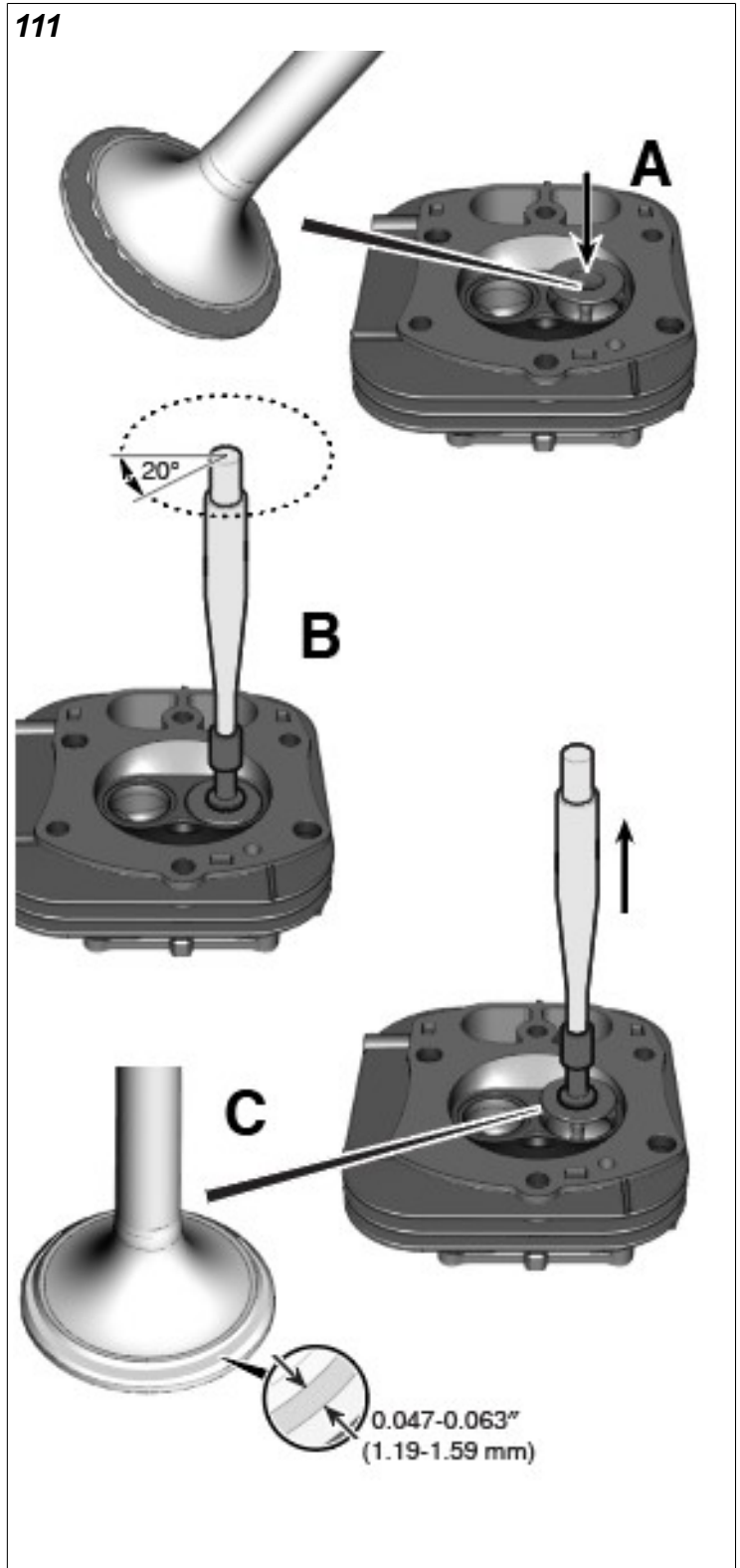
- Replace the valve if bent or if there is evidence of burning or cracking.
- Inspect the end of the valve stem for pitting or uneven wear. Replace the valve if either of these conditions are found.
- Inspect the valve stem retainer groove for burrs, damage or excessive wear. Remove burrs with a fine tooth file if found.
- Polish the valve stem with fine emery cloth or steel wool to remove carbon buildup.
- Measure the top, center and bottom of the intake valve stem using an outside micrometer (A, Figure 110). Replace the intake valve if any measurement is **0.228 in** (5.791 mm) or less.

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- Measure the top, center and bottom of the exhaust valve stem. Replace the exhaust valve if any measurement is **0.228 in** (5.791 mm) or less.
- Hold each valve against a worn wire wheel in a bench grinder to remove all carbon deposits from the valve head and face, but exercise caution to avoid removing any metal material.

8. Inspect intake valve face and seat. If only minimal wear is found, lap the valve face and seat as follows:
 - A. Obtain Valve Lapping Compound (see *SECTION 9 - SPECIFICATIONS - Engine Fluid and Sealant Specifications*).
 - B. Apply lapping compound sparingly around the entire valve face and valve seat.
 - C. Lightly lubricate the valve guide and valve stem with clean engine oil.
 - D. From the bottom of the cylinder head, insert the valve stem into the valve guide (**A**, Figure 111).



- E. Push on bottom of valve until it contacts the valve seat.
- F. Obtain the Valve Lapping Tool (see *SECTION 3 - TROUBLESHOOTING - Special Tool List*).
- G. Attach suction cup at end of tool to valve head (**B**). Holding shank of tool between the palms of both hands, oscillate the tool approximately 20° back and forth a few times.

- H. Remove valve from the cylinder head and thoroughly clean the valve face and valve seat of any lapping compound. Use a clean rag dipped in mineral spirits for good results.
- I. Carefully inspect the seating surface on the valve face (C). A properly lapped valve shows a gray, frosty seating surface located near the center of the valve face. Verify that the lapped surface extends evenly and completely around the entire valve face with a contact area **0.047-0.063 inches** (1.19-1.59 mm) wide.

Carefully inspect the seating surface on the valve seat. The valve seat should also show an unbroken lapped finish of uniform width.

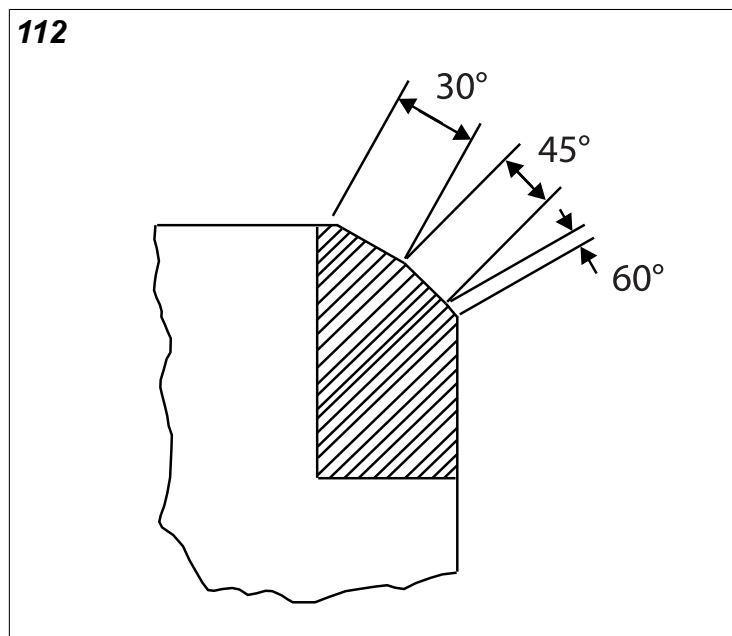
9. If the desired results are not observed, obtain a valve seat cutting tool kit. For engines equipped with 3-angle valve seats, see Figure 112, and proceed as follows. For engines equipped with single-angle valve seats, go to step 11.

NOTE: Carefully read manufacturer's directions for proper assembly and use of valve seat cutting tool.

- A. Install the proper sized pilot in the intake valve guide.

NOTE: Do not drop the cutter onto the valve seat during installation or removal, as the blades may cause seat damage that requires additional cutting.

NOTE: Applying too much pressure or rotating the cutter too fast will produce chatter marks that adversely affect sealing integrity. Rotate the cutter slowly, so that it takes about three seconds to make one complete rotation.



- B. Install the 60° cutter on the pilot to make the bottom-narrowing cut. Rotate the cutter three or four turns, so that it cuts all the way around the valve seat.
- C. Install the 30° cutter to make the top-narrowing cut.
- D. Install the 45° base angle cutter and cut the seat contact area until it is approximately **0.047-0.063 inches** (1.19-1.59 mm) wide.
- E. Use low pressure compressed air to thoroughly remove all cutting chips and metal shavings. Remove pilot from valve guide.
- F. Lap the valve face and seat a second time to verify location and width of the seat contact area.
- G. If the seat contact area is too narrow, recut using the 45° base angle cutter.
- H. If the seat contact area is too wide, repeat steps 9(B) and 9(C).
10. Perform steps 8-9 on the exhaust valve.

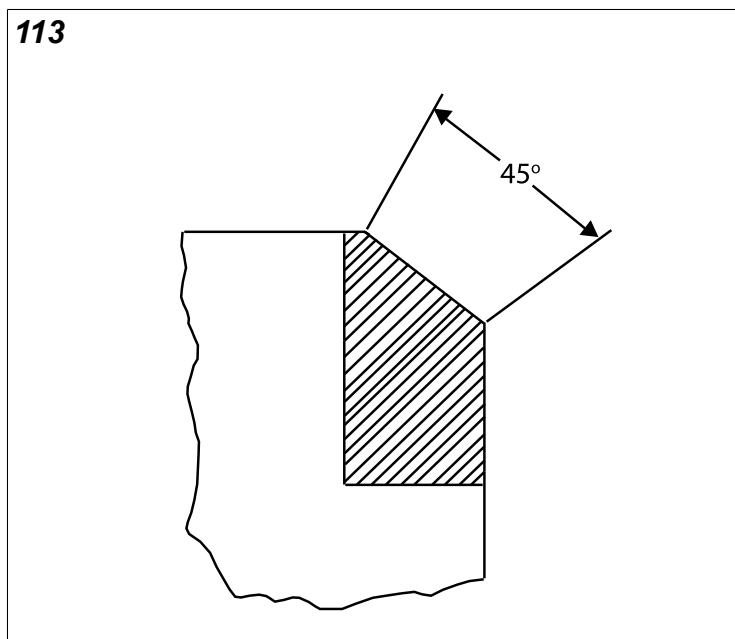
11. For engines equipped with single-angle valve seats, see Figure 113 and proceed as follows:

NOTE: Carefully read manufacturer's directions for proper assembly and use of valve seat cutting tool.

- A. Install the proper sized pilot in the intake valve guide.

NOTE: Do not drop the cutter onto the valve seat during installation or removal, as the blades may cause seat damage that requires additional cutting.

NOTE: Applying too much pressure or rotating the cutter too fast will produce chatter marks that adversely affect sealing integrity. Rotate the cutter slowly, so that it takes about three seconds to make one complete rotation.



- B. Install the 45° base angle cutter and cut the seat contact area until it is approximately **0.047-0.063 inches** (1.19-1.59 mm) wide.
- C. Use low pressure compressed air to thoroughly remove all cutting chips and metal shavings. Remove pilot from valve guide.
- D. Lap the valve face and seat a second time to verify location and width of the seat contact area.
- E. If the seat contact area is too narrow, recut using the 45° base angle cutter.
- F. Repeat steps 8 and 10 on the exhaust valve.

Valve Springs

1. Inspect valve springs for broken or discolored coils. Replace springs if either of these conditions are found.
2. Set the intake and exhaust valve springs on a level surface and use a straightedge to check for proper squareness and equivalent height. Too much height may correspond to a reduction in spring pressure which results in sluggish valve action.

Valve Spring Retainers/Tapered Keepers Inspection

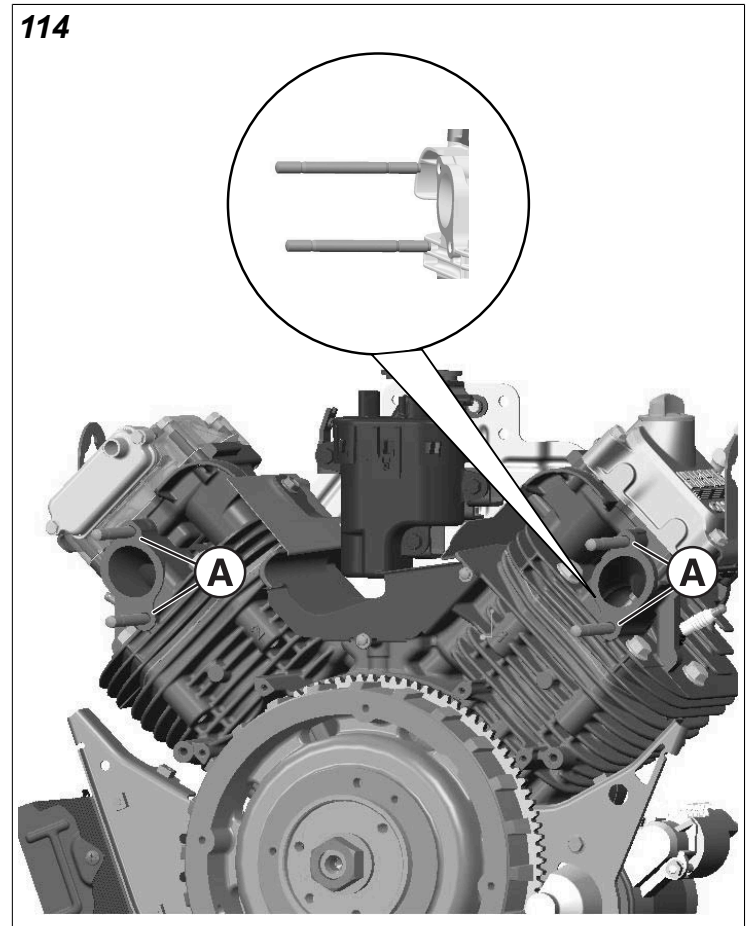
1. Inspect parts for rust pits or corrosion. Replace as necessary.
2. Inspect inside diameter of valve spring retainers for damage or excessive wear. Center must be well defined without distortion.
3. Inspect inside of tapered keepers for excessive wear. Upraised center must be well defined and fit snugly in valve stem grooves. Place keepers into grooves and verify that they grip tightly without sliding.

Tappets, Push Rods, Adjuster Screws, and Rocker Arms

1. Inspect tappet and valve adjuster screw sockets for signs of scuffing, pitting or general wear.
2. Tappet faces may appear to have smooth surfaces, but still have concave wear. Hold a straight edge across the tappet face. Any concave wear found on the tappet faces may also indicate worn camshaft lobes.
3. Roll push rods on a flat surface to determine if they are bent. Replace push rods that are bent, dented, broken or discolored. Replace the push rod if the ball ends show signs of excessive wear or damage. For best practices, replace push rods in pairs.
4. Check rocker arms for uneven wear or pitting where contact is made with the valve stem tips. Replace the rocker arm if excessive wear is found, or if pitted, deformed, or scored.

Intake Manifold Studs

1. Inspect intake manifold studs (A, Figure 114). Replace studs if broken, bent, or if severe thread damage is observed.



2. Replace stud as follows:

A. Loosen stud using a T-20 TORX bit.

NOTE: If stud is difficult to remove, apply a suitable penetrating oil to threads, and then work stud in and out until it moves freely.

B. Remove stud from cylinder head.

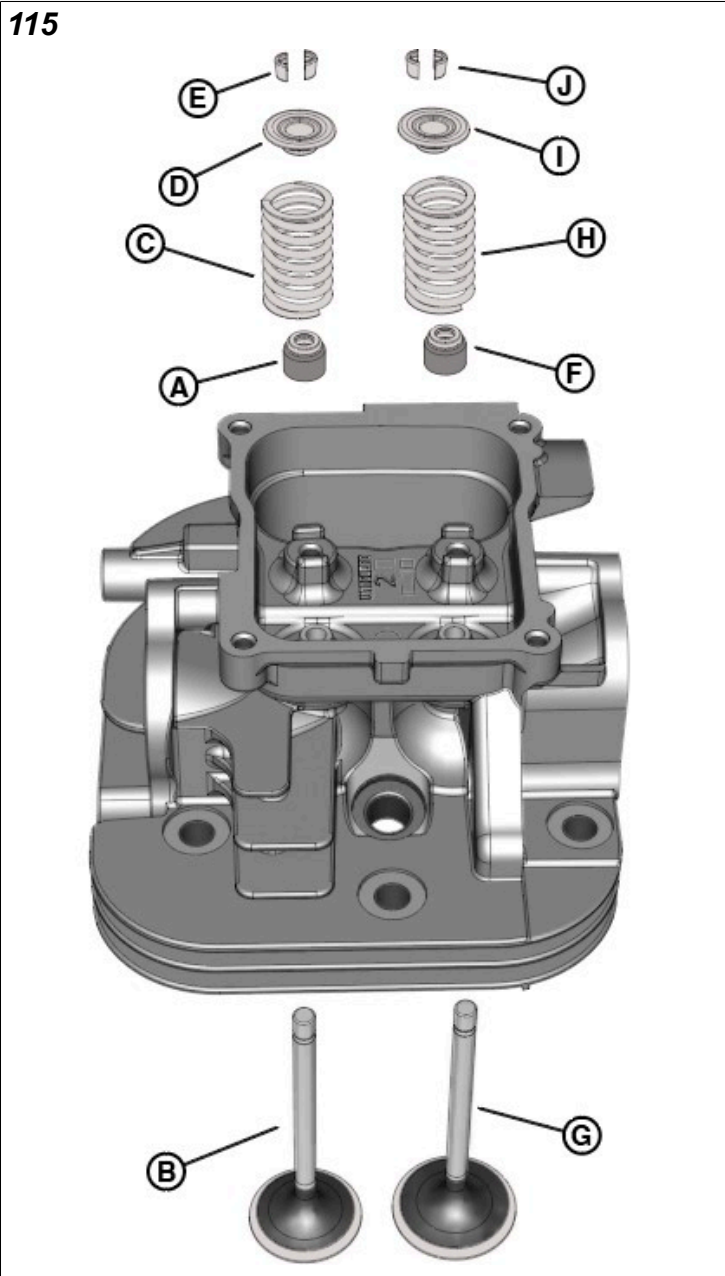
C. With the TORX recess on the outside, install **new** stud by hand, and then tighten to **45 lb-in (5 Nm)**.

Assembly

1. Pack shop towels into the combustion chamber and place cylinder head on bench with the combustion chamber side down.

2. Install exhaust valve assembly as follows:

- A. Lightly lubricate inside diameter **new** valve stem seal (A, Figure 115) with clean engine oil. Place seal squarely over valve guide. Obtain a suitable socket or seal installation tool, and using a small hammer, gently tap end of tool until seal lightly bottoms on cylinder head.

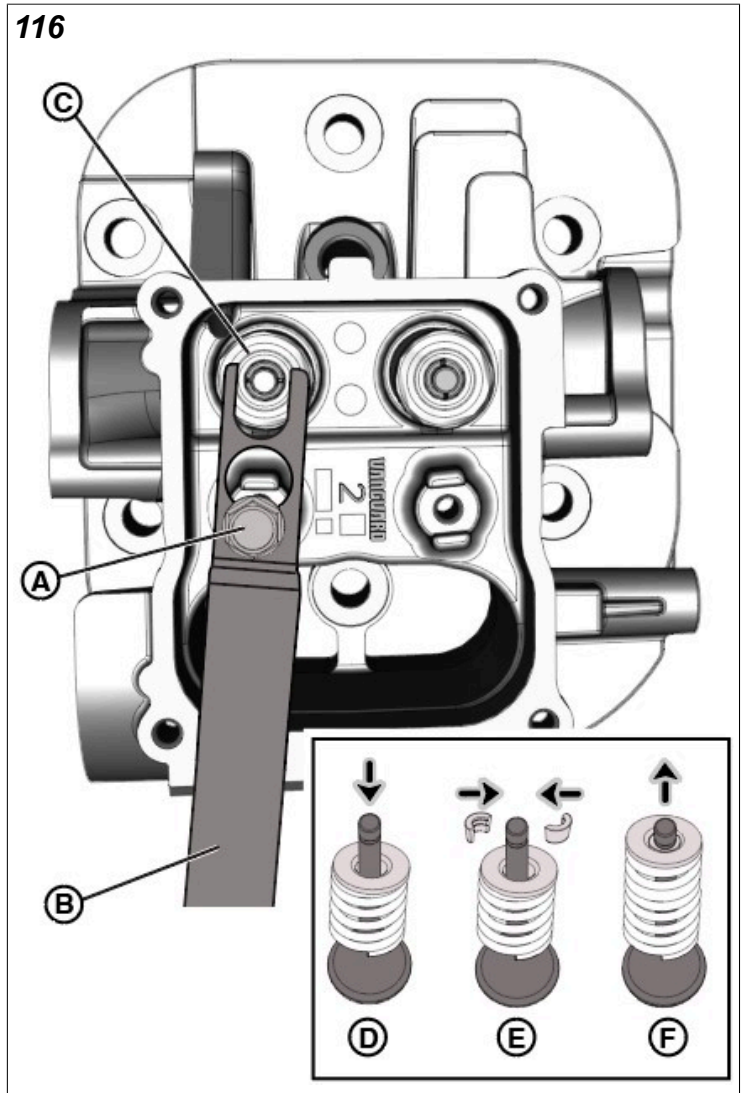


- B. Inspect valve stem groove for burrs that could damage the valve stem seal during installation. Remove any slight burrs with a fine-tooth file. Lightly lubricate valve stem groove with clean engine oil.
- C. Apply a suitable engine assembly lube to the valve stem.

NOTE: If the valves were not tagged during disassembly, remember that the exhaust valve (B) always has the smaller valve face diameter.

- D. From the bottom of the cylinder head, insert the valve stem into the valve guide.

- E. To distribute the assembly lube evenly around the valve stem and guide, hand spin the valve as it is installed. Work the valve back and forth in the bore to verify that it slides smoothly and seats properly.
- F. Using a suitable degreaser, thoroughly clean valve face, valve guide, and end of valve stem of any excess assembly lube.
- G. Install valve spring (C) over the valve stem and valve guide until seated on machined surface of the cylinder head.
- H. Set the valve spring retainer (D) on top of the valve spring.
- I. Install fulcrum screw (A, Figure 116) and tighten until positive thread engagement is obtained.



- J. Obtain Valve Spring Compressor (B). See SECTION 3 - TROUBLESHOOTING - Special Tool List.
- K. Place tool over head of fulcrum screw engaging small end of slot.
- L. With prongs of tool on valve spring retainer (C), pivot tool to compress valve spring (D).

- M. Fit the tapered keepers (E) into the valve stem groove with the tapered side down. For best results, apply a suitable engine assembly lube to the inside of the keepers before installation. Arrange keepers so that the gap is evenly spaced, and release the valve spring compression (F).
 - N. Remove tool and fulcrum screw.
 - O. Verify that the axis of the valve spring is parallel to the valve stem. A slanting or leaning valve spring will result in premature valve guide wear.
3. Repeat step 2 to install intake valve assembly.
 4. Repeat steps 1-3 to install valve assemblies on second cylinder head.
 5. Cover the cylinder head to protect it from dust and dirt until time of installation.

PISTON AND CONNECTING ROD

Disassembly

1. Insert small pick into pick lock groove and pull piston pin lock ring out of pin boss groove (see Figure 117). Discard lock ring.

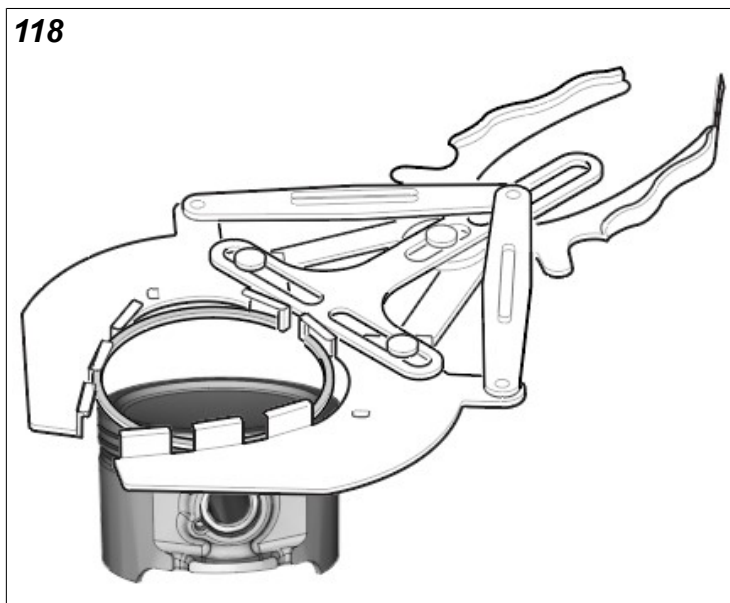
117



2. Push piston pin toward open pin boss to remove from piston and upper connecting rod.
3. Obtain the Piston Ring Expander tool. See SECTION 3 - TROUBLESHOOTING - Special Tool List.

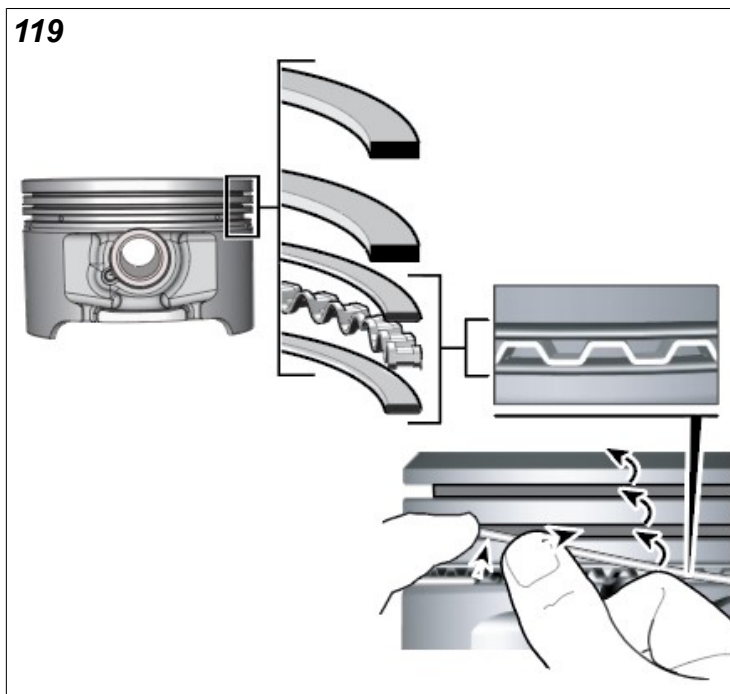
4. Remove compression ring from the top ring groove. See Figure 118.

118



5. Remove oil wiper ring from the middle ring groove.
6. Remove oil control ring from the bottom ring groove. Proceed as follows:
 - Remove the expander spring.
 - Spiral or wind the upper steel rail from the bottom ring groove into the middle ring groove (see Figure 119). Repeat action to move the rail into the top ring groove and then off the piston.
 - Repeat above step to remove the lower steel rail.

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Cleaning

Piston

1. Do not sand blast or glass bead blast piston. Bead blasting rounds the ring lands and will result in high oil consumption and blow-by of exhaust gases. Blow-by of exhaust gases contaminates the engine oil supply, and reduces engine efficiency by weakening the combustion seal necessary for efficient transfer of energy to the piston.
2. To remove all carbon and combustion deposits, soak the piston in a special detergent that will not corrode aluminum. Maintain the temperature of the cleaning solution well below 212° F (100° C).
3. Thoroughly rinse the piston and dry with moisture free compressed air.
4. Thoroughly clean the three piston ring grooves of all carbon deposits. A broken compression ring properly ground to a sharp chisel-like edge can be used for this purpose.
5. Verify that the piston pin lock ring groove is clean and free of dirt and grime.
6. Clean oil drain back holes leading from the oil control ring groove to the underside of the piston crown. Use a soft bristle brush and compressed air to ensure cleanliness. Do not use a wire brush or the holes may be enlarged.
7. If present, verify that set of oil drain back holes at top of piston skirt are clean and open.

Connecting Rod

1. Thoroughly clean parts in a non-volatile cleaning solution or solvent. Follow up with a thorough wash in hot soapy water.
2. Blow dry with low pressure compressed air.
3. Verify that oil holes in connecting rod shank and at top of piston pin bore are clean and open.

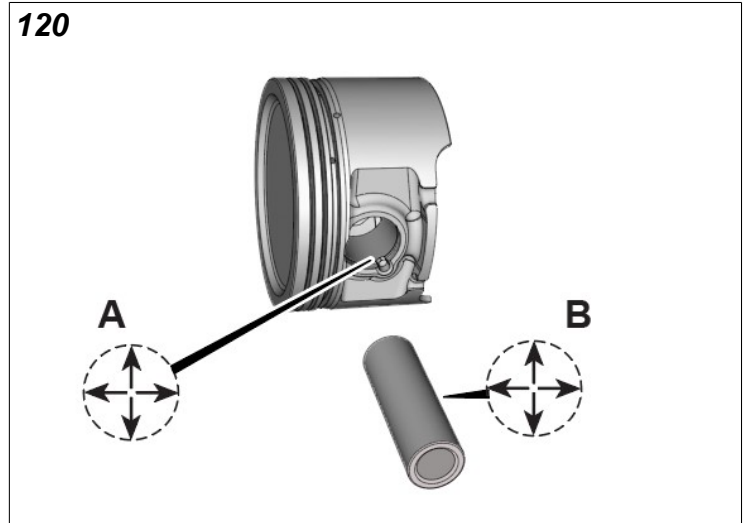
Inspection

Piston and Pin

1. Carefully inspect the piston for damage or excessive wear. Proceed as follows:
 - A. Inspect the piston for cracks. Pay special attention to the area around the pin bores and oil drain back holes beneath the piston crown.
 - B. Check piston for cracked, broken or bent ring lands.
 - C. Check piston skirt for cracks, gouges, deep scratches or heavy scoring.
 - D. Check piston head for evidence of burning, etching or melting.
 - E. Look for marks or imprints caused by contact with valves.

NOTE: A piston with superficial wear marks, minor scratching or mild scoring may continue to be used.

2. Lightly oil, with clean engine oil, a good piston pin and insert it into the piston pin bore to feel for proper fitment. The pin should slide in and out without binding, but also without pivoting or rocking.
3. Using an inside micrometer or dial caliper, measure the piston pin bore diameter at two locations - parallel and perpendicular to the crankshaft (**A**, Figure 120). Replace the piston if either measurement is **0.826 in** (20.970 mm) or more.



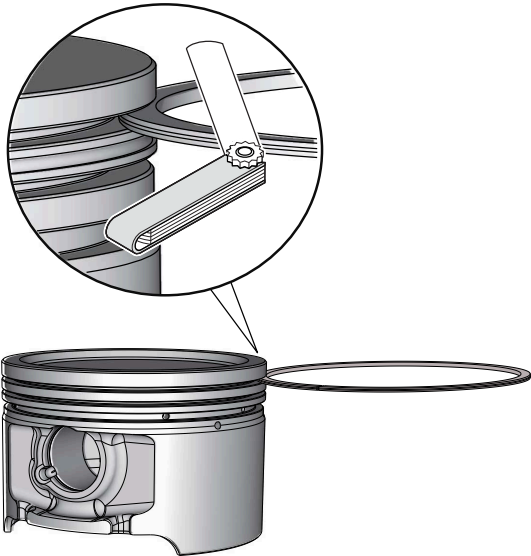
4. Using an outside micrometer, measure the outside diameter of the piston pin at two locations- parallel and perpendicular to the crankshaft (**B**). Replace piston pin if either measurement is **0.829 in** (21.063 mm) or less.
5. Run your index finger around the edge of the piston crown to feel for dings, nicks or burrs. Lightly file the edge of the crown to remove any defects.

6. Measure the piston ring side clearance as follows:

NOTE: Worn ring grooves result in high oil consumption and blow-by of exhaust gases. Blow-by of exhaust gases contaminates the engine oil supply, and reduces engine efficiency by weakening the combustion seal necessary for efficient transfer of energy to the piston.

- A. Insert the edge of a **new** compression ring into the top piston ring groove. Insert a feeler gauge between the upper surface of the ring and the ring land (see Figure 121).

121



- B. Since the grooves wear unevenly, repeat this check at several locations around the piston ring groove circumference.
- C. Discard the piston if any measurement is **0.044 in** (1.11 mm) or more.

NOTE: Only the top compression ring side clearance needs to be checked.

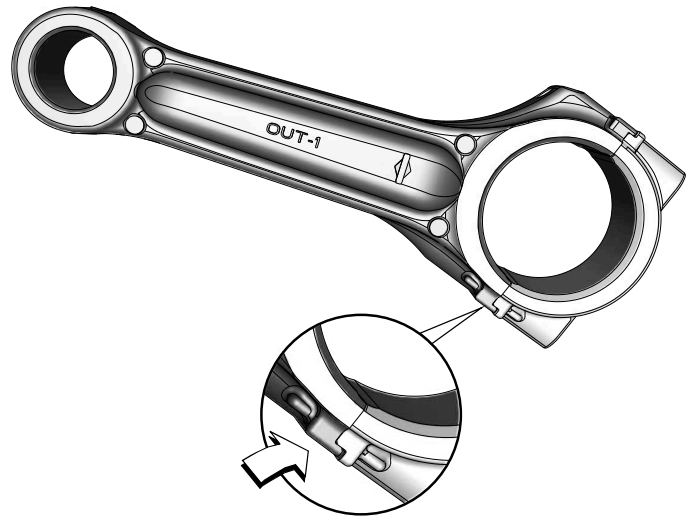
Connecting Rod

1. Inspect the connecting rod for cracks, twisting or bending.
2. Inspect bearing surfaces for scratches or scoring.
3. Inspect dipper on connecting rod cap for bending, chipping, or cracking.

NOTE: Replace connecting rod and cap if any of the above conditions are found. Always replace connecting rod and cap as an assembly

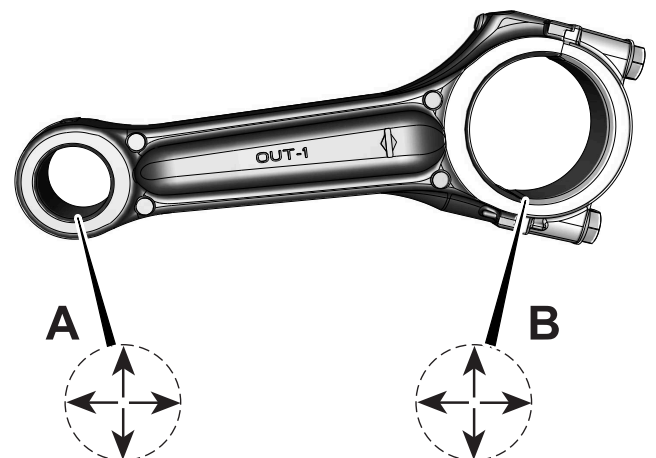
4. Install the connecting rod cap to the connecting rod so that the marks on the connecting rod cap and shank are aligned (see Figure 122). Start the 2 fasteners by hand, then tighten to **130 lb-in** (14.7 Nm).

122



5. Obtain Telescoping Gauge (see *Special Tool List*) and inside micrometer or plug gauge.
6. Measure piston pin bearing bore diameter at two locations- parallel and perpendicular to the crankshaft (**A**, Figure 123). Replace connecting rod if either measurement is **0.830 in** (21.082 mm) or more.

123



7. Measure the crank pin bearing bore diameter at two locations- parallel and perpendicular to the crankshaft (**B**). Replace the connecting rod if either measurement is **1.698 in** (43.13 mm) or more.
8. Remove two hex flange screws to release connecting rod cap.

Assembly

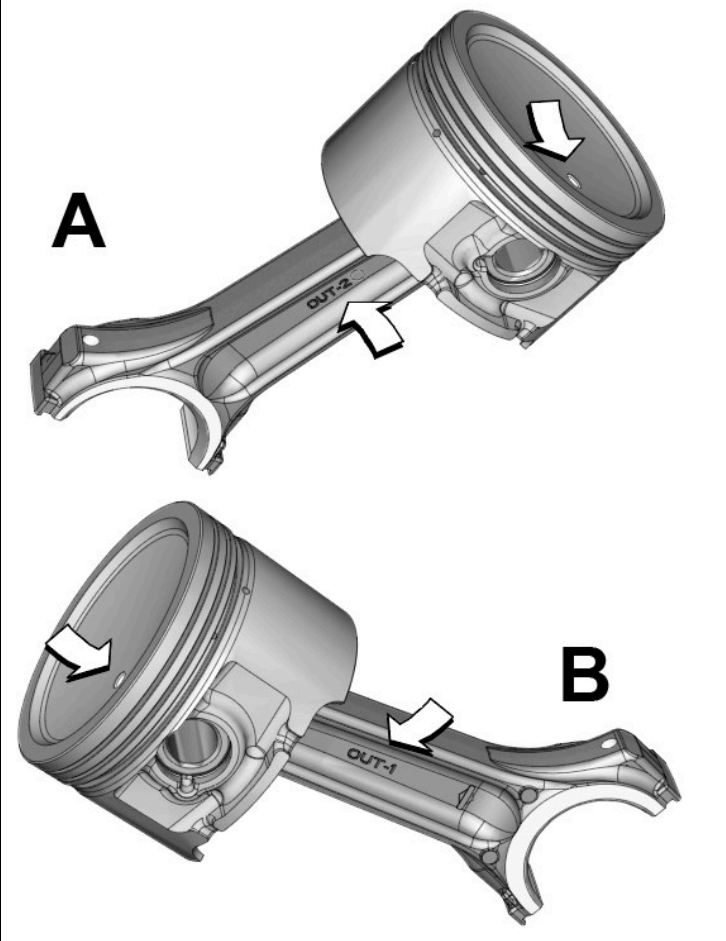
1. Apply clean engine oil to piston pin, piston pin bosses, and upper connecting rod bearing.

NOTE: For the longest service life, preserve existing wear patterns by installing parts in their original locations.

2. Place piston over small end of connecting rod, so that the locating dot on the piston crown is on the same side as:

Cylinder 1	OUT-1 rod stamp	See B in Figure 124.
Cylinder 2	OUT-2 rod stamp	See A in Figure 124.

124



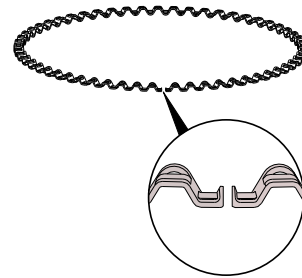
NOTE: When assemblies are installed in the crankcase, cylinder 1 rod **OUT-1** stamp and cylinder 2 rod **OUT-2** stamp will be visible through the crankcase cover opening.

3. Insert piston pin through piston pin bore and upper connecting rod bearing. Push pin until it contacts opposite pin boss.

NOTE: Do not reuse piston pin lock ring after it has been removed. The lock ring may weaken or become distorted during removal causing it to break or dislodge during engine operation.

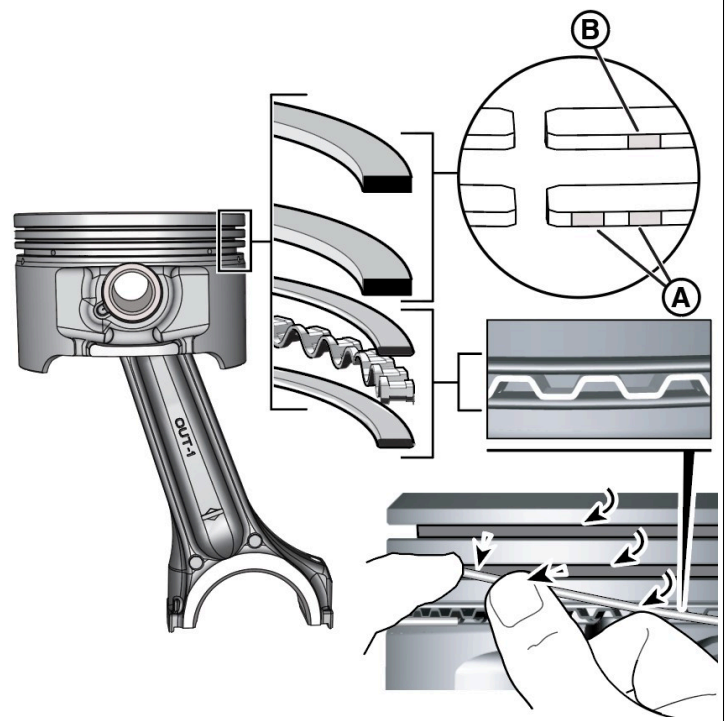
4. Install **new** piston pin lock ring into pin bore groove, so that end of the lock ring is 90° from the pick lock groove. Exercise care to avoid kinking, stretching, or distorting lock ring. Verify that lock ring is fully seated in the groove.
5. Use compressed air to remove any dirt or dust that may have settled in the oil drain back holes and piston ring grooves.
6. Apply clean engine oil to three piston ring grooves.
7. Install the oil control ring into the bottom ring groove. Proceed as follows:
 1. Install expander spring, so that the gap ends point toward the piston crown (see Figure 125).

125



2. Spiral bottom oil rail into space below expander spring (see Figure 126).

126



3. Spiral top oil rail into space above expander spring.

- Obtain the Piston Ring Expander (see *SECTION 3 - TROUBLESHOOTING - Special Tool List*).

NOTE: Always use the piston ring expander to prevent excessive ring twist and expansion. Over expansion may cause the ring to crack opposite the ring gap. Damaged or distorted rings result in blow-by of exhaust gases, increased oil consumption, and lower service life of valves and other components.

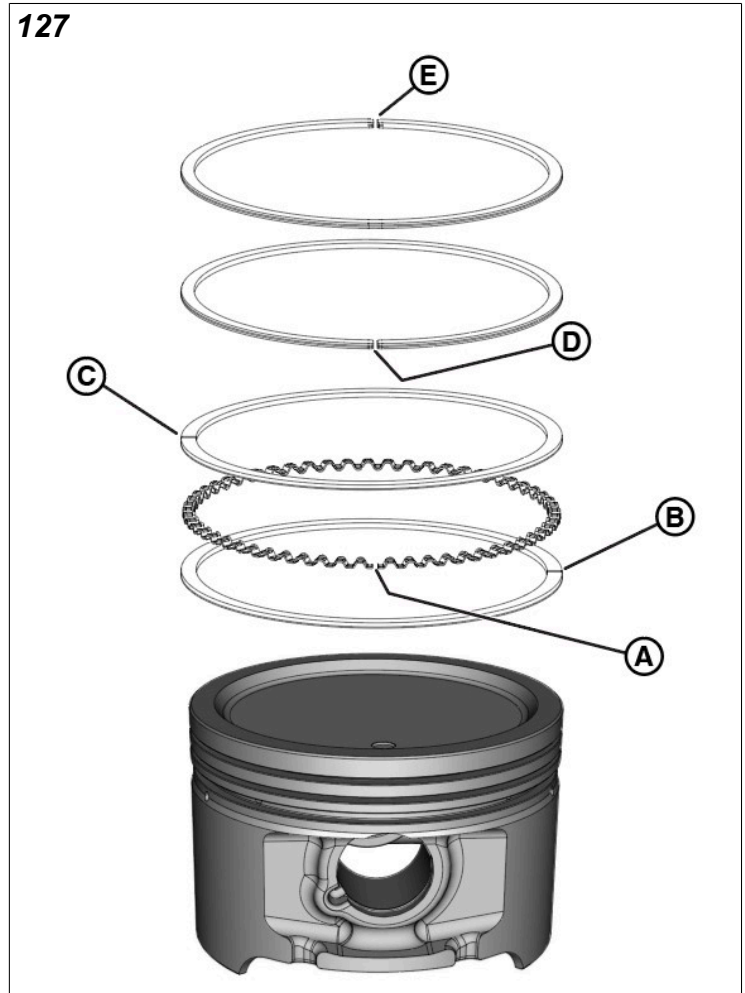
- Carefully install the oil wiper ring (**A**, Figure 126) into the middle ring groove, so that the two painted marks are to the right of the ring end gap.

NOTE: Installing the oil wiper ring upside down will cause oil to be scraped up into the combustion chamber resulting in excessive oil consumption and lower service life on valves and other components.

- Carefully install the compression ring (**B**) into the top ring groove, so that the single painted mark is to the right of the ring end gap.
- Rotate piston rings using the palms of both hands. Verify that the rings rotate freely without sticking.

- Stagger the ring gaps around the piston. Proceed as follows:

- Rotate expander spring, so that the gap is positioned at the front of the piston (**A**, Figure 127).



- Rotate bottom oil rail to position the gap 90° from the gap in the expander spring (**B**).
- Rotate top oil rail to position the gap 180° from the gap in the bottom oil rail (**C**).
- Rotate the middle oil wiper ring to align the gap with the gap in the expander spring (**D**).
- Rotate the top oil compression ring to position the gap 180° from the gap in the oil wiper ring (**E**).

FLYWHEEL, CRANKSHAFT AND CAMSHAFT

Cleaning

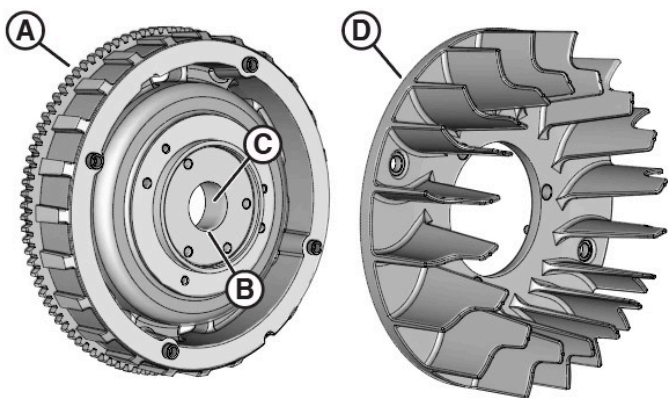
1. Thoroughly clean parts in a non-volatile cleaning solution or solvent. Follow up with a thorough wash in hot soapy water.
2. Blow dry with low pressure compressed air.

Inspection

Flywheel

1. Inspect flywheel magnet for cracks, chips, or other damage. Check magnet for looseness.
2. Check flywheel ring gear (A, Figure 128) for worn, cracked, chipped, or missing teeth.

128

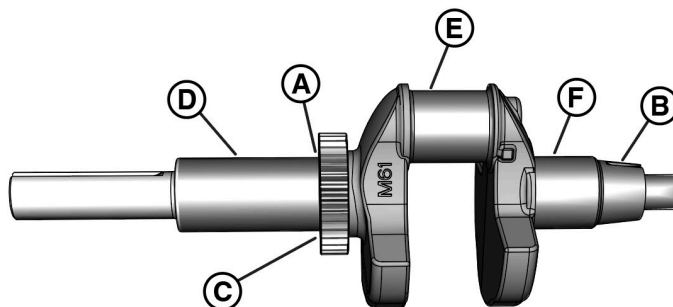


3. Inspect flywheel key for partial or complete shearing. Replace key if any damage is found. See *Inspection - Crankshaft* in this section.
4. Inspect flywheel keyway (B) for damage or distortion.
5. Inspect flywheel taper (C) for scoring, scratches, cracks, or burrs. Remove any slight burrs with a fine-tooth file.
6. Inspect flywheel fan (D) for bent, cracked, chipped, or broken fins.

Crankshaft

1. Carefully remove crankshaft end play shims (A, Figure 129), if present. Count shims as they are removed to be sure of installing the correct number when the engine is assembled. Inspect shims for tears, holes, or other damage. Replace shims as necessary.

129

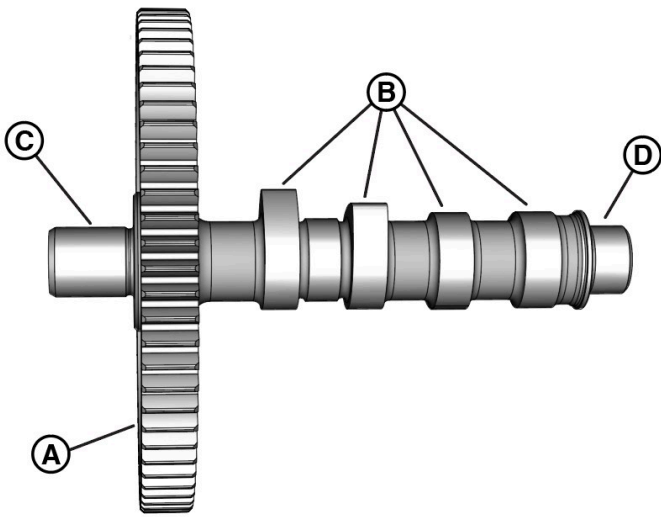


2. Inspect keyway (B) for damage or distortion.
3. Check camshaft gear (C) for worn, cracked, chipped, or missing teeth.
4. Inspect crankshaft for straightness. **DO NOT** attempt to straighten bent crankshafts.
5. Inspect crankshaft taper for burrs, rust or other damage. Remove any slight burrs with a fine-tooth file.
6. Inspect crankshaft PTO bearing journal (D), crankpin journal (E), and MAG bearing journal (F) for scoring.
7. Using an outside micrometer, measure the crankpin journal diameter. Replace the crankshaft if measurement is **1.691 in** (42.95 mm) or less.
8. Measure the MAG bearing and PTO bearing journal diameters. Replace the crankshaft if either measurement is **1.769 in** (44.926 mm) or less.

Camshaft

1. Check camshaft gear (A, Figure 130) for worn, cracked, chipped, or missing teeth.

130



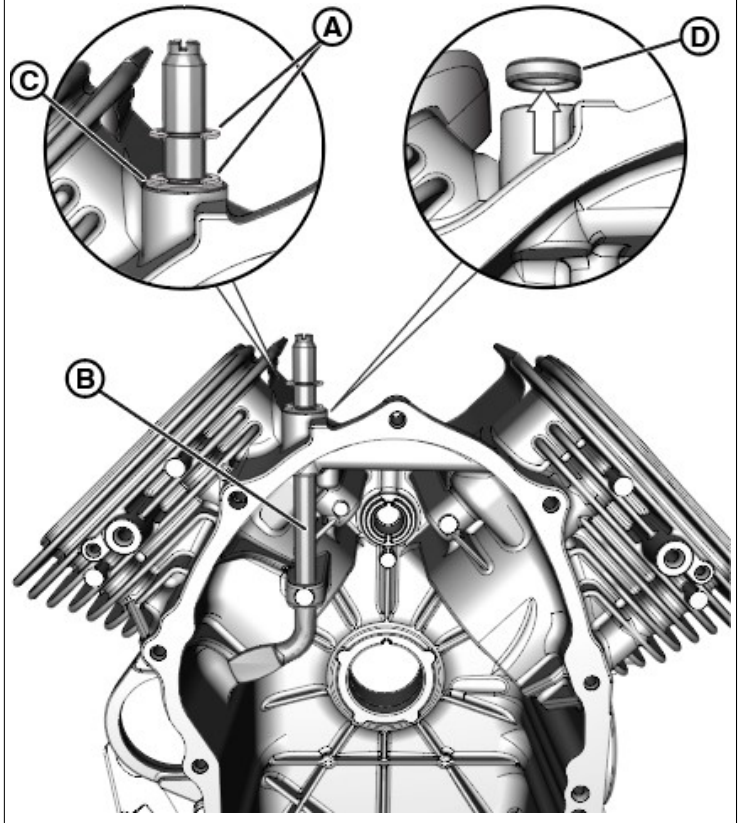
2. Check camshaft lobes (B) for scratching, scoring, or excessive wear.
3. Check MAG bearing journal (C) and PTO bearing journal (D) for scratching or scoring.
4. Using an outside micrometer, measure the MAG bearing journal and PTO bearing journal diameters. Replace the camshaft if either measurement is **0.783 in (19.897 mm)** or less.

CRANKCASE AND CRANKCASE COVER

Governor Shaft and Seal - Disassembly

1. If equipped, remove C-clips (A, Figure 131) from top 2 grooves in governor shaft (B) and bottom groove within the crankcase. Discard C-clips.

131



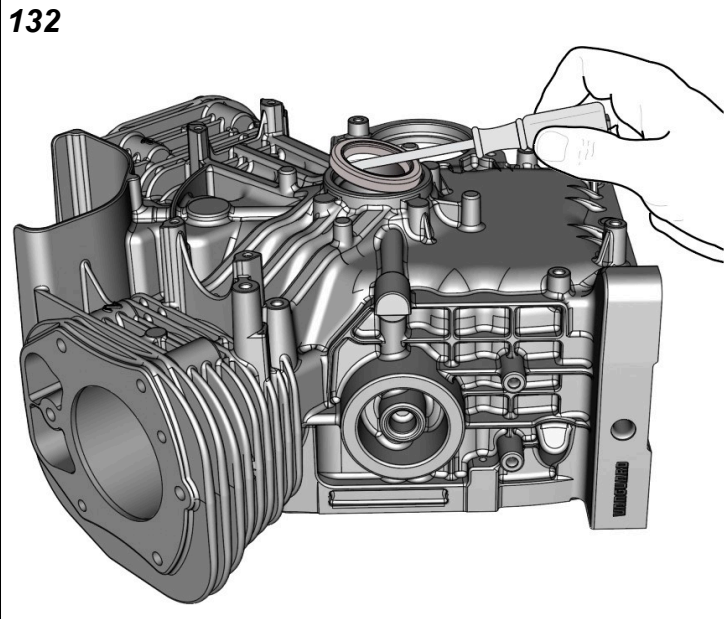
2. Remove flat washer (C) from crankcase boss.
3. Remove governor shaft from inside crankcase.
4. Using a small pick, remove oil seal (D) from crankcase bore. Exercise caution to avoid scratching bore during seal removal.

Governor Shaft and Seal - Assembly

1. Install **new** governor shaft oil seal (D, Figure 131). Press seal into shaft bore until seal edge is level with bore lip.
2. From inside the crankcase, install the governor shaft (B) up through the crankcase shaft bore. Make sure to avoid damaging the new oil seal. Make sure that the paddle of the governor shaft is orientated as pictured in Figure 131.
3. Install the flat washer (C) over the governor shaft and onto the crankcase boss.
4. If equipped, install **new** C-clips onto the top 2 grooves of the governor shaft and on the bottom groove within the crankcase.

MAG Bearing Oil Seal - Disassembly

1. Using Figure 132 as a reference, remove and discard oil seal from crankcase bearing bore. Exercise care to avoid scratching bearing bore during removal.



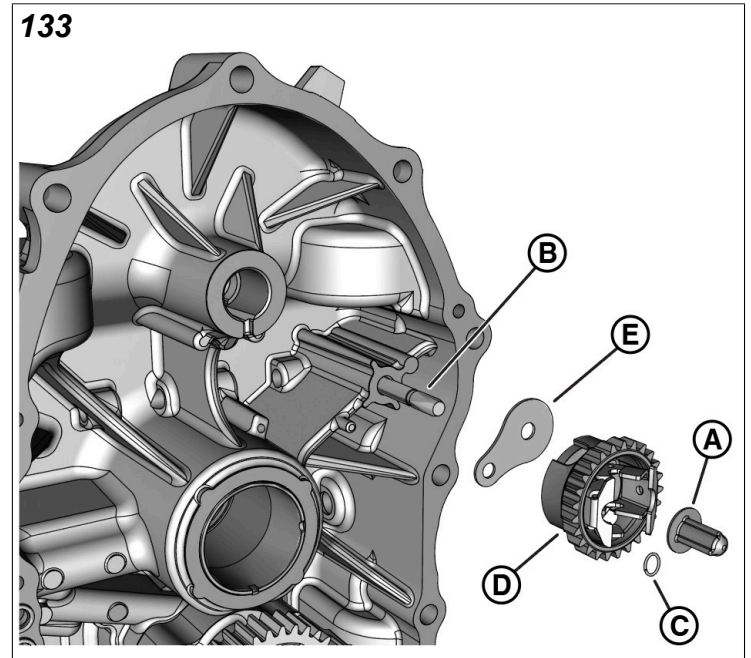
MAG Bearing Oil Seal - Assembly

1. Apply a thin film of clean engine oil to oil seal bore and OD of **new** oil seal.
2. Place oil seal into the bearing bore.
3. Place the suitable oil seal driver on outside edge of oil seal.
4. Center the oil seal driver under the ram.
5. Slowly apply pressure to oil seal driver until the oil seal is **flush to 0.040 in** (0-1.0 mm) below the bearing bore lip.

Crankcase Cover

Governor Gear - Disassembly

1. Remove governor cup (A, Figure 133) from governor shaft (B).



2. Remove retaining ring (C) from groove in governor shaft. Discard retaining ring.
3. Remove the governor gear/weight assembly (D).
4. Remove thrust washer (E) from governor shaft and crankcase locating nub.

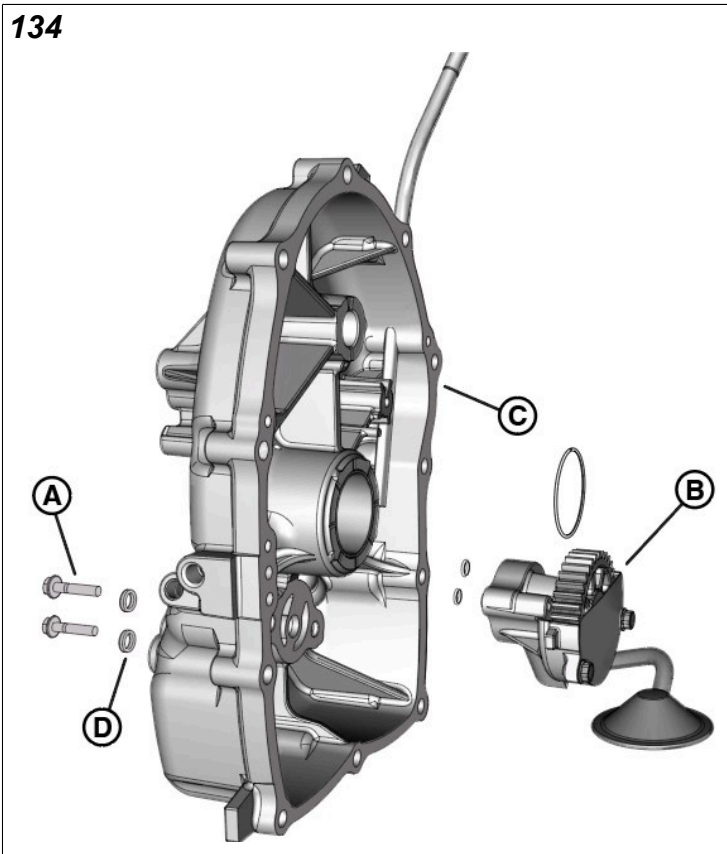
Governor Gear - Assembly

1. Install the thrust washer (E, Figure 133) onto the governor shaft and crankcase locating nub.
2. Install the governor gear/weight assembly (D) onto the governor shaft (B).
3. Install **new** retaining ring (C) onto groove in governor shaft.
4. Install governor cup (A) onto the governor shaft.

Oil Pump - Horizontal Shaft Engines - Disassembly

The following procedure applies to **horizontal shaft** engines.

1. Remove 2 fasteners (**A** Figure 134) to release oil pump (**B**) from crankcase cover (**C**).



2. Remove o-rings (**D**) from screws and discard.

Oil Pump - Horizontal Shaft Engines - Assembly

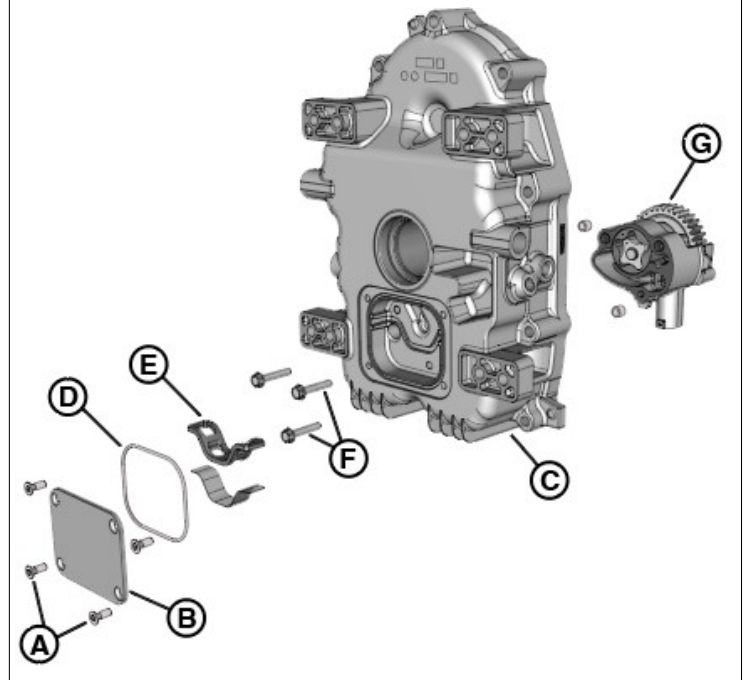
1. Install the oil pump (**B**, Figure 134) onto the crankcase cover with **new** O-rings and seals.
2. Install **new** O-rings (**D**) onto the 2 oil pump fasteners.
3. Start by hand the 2 oil pump fasteners. Tighten to **90 lb-in** (10.2 Nm).

Oil Pump - Vertical Shaft Engines - Disassembly

The following procedure applies to **vertical shaft** engines.

1. Remove 4 fasteners (**A**, Figure 135) to release cover (**B**) from crankcase cover (**C**).

135



2. Remove o-ring (**D**) from crankcase cover groove. Discard O-ring.
3. Remove oil intake filter (**E**) from crankcase cover.
4. Remove 3 fasteners (**F**) to release oil pump (**G**) from crankcase cover.

Oil Pump - Vertical Shaft Engines - Assembly

1. Install the oil pump (**G**, Figure 135) onto the crankcase cover, aligning the 3 fastener holes.
2. Start by hand the 3 oil pump fasteners (**F**). Tighten to **90 lb-in** (10.2 Nm).
3. Install the oil intake filter (**E**) onto the crankcase cover.
4. Install **new** o-ring (**D**) into crankcase cover groove.
5. Install the cover (**B**) onto the crankcase cover.
6. Start by hand the 4 cover fasteners. Tighten to **90 lb-in** (10.2 Nm).

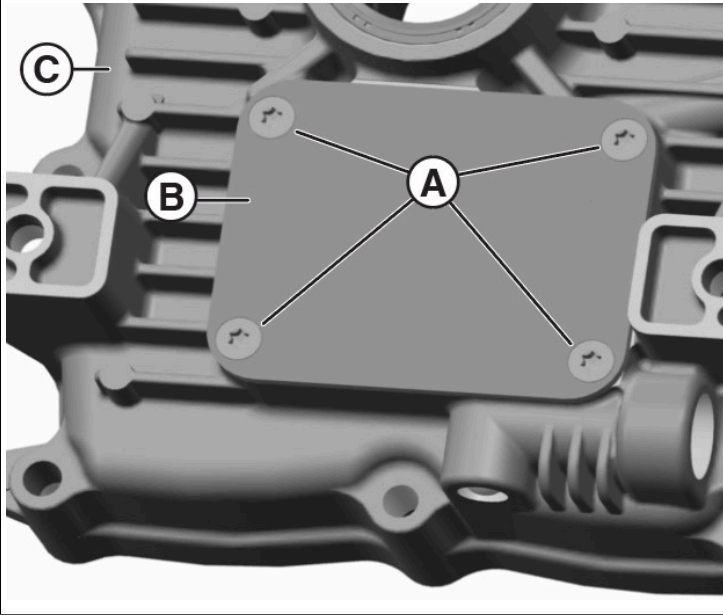
Optional Oil Guard System - Disassembly

Oil Guard Oil Supply Pump - Removal

Remove the oil supply pump from the crankcase cover as follows:

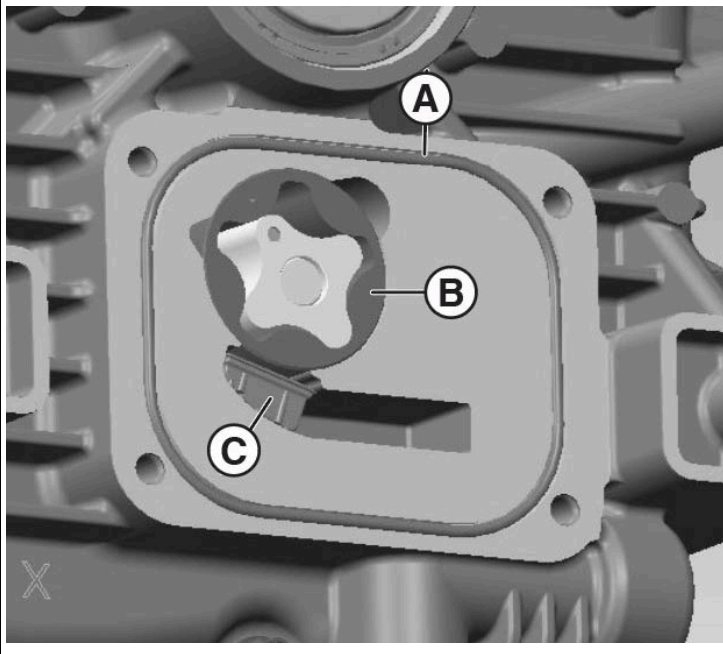
1. Remove 4 fasteners (A, Figure 136) to release the oil supply pump gerotor cover (B) from crankcase cover (C).

136



2. Remove o-ring (A, Figure 137) from the crankcase cover groove.

137



3. Remove inner and outer gerotors (B) from the gear shaft.
4. Remove oil filter screen (C).

5. Remove roll pin (A, Figure 138) from hole in gear shaft.

138



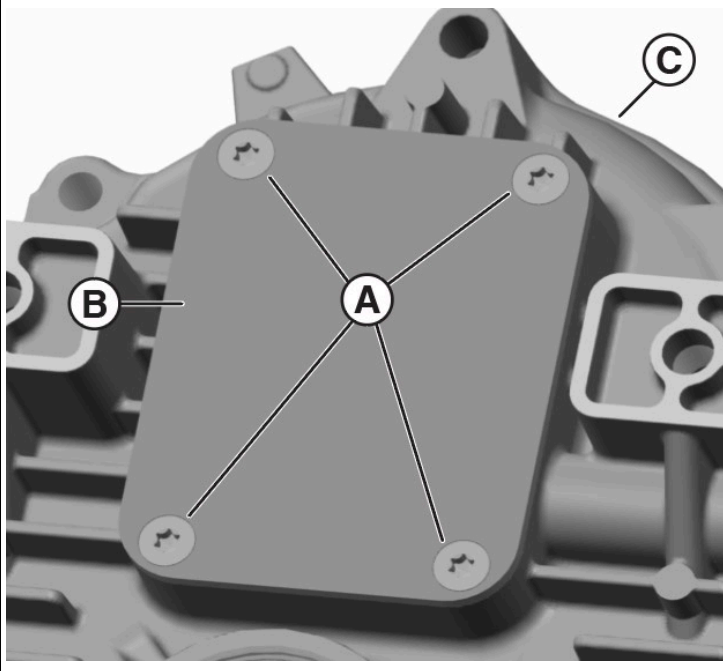
6. Remove crescent ring (B) from the groove on the gear shaft.
7. Remove thrust washer (C) from gear shaft.
8. On the opposite side of crankcase cover, remove gear shaft assembly from crankcase cover.

Oil Guard Oil Scavenge Pump - Removal

Remove the oil scavenge pump from the crankcase cover as follows:

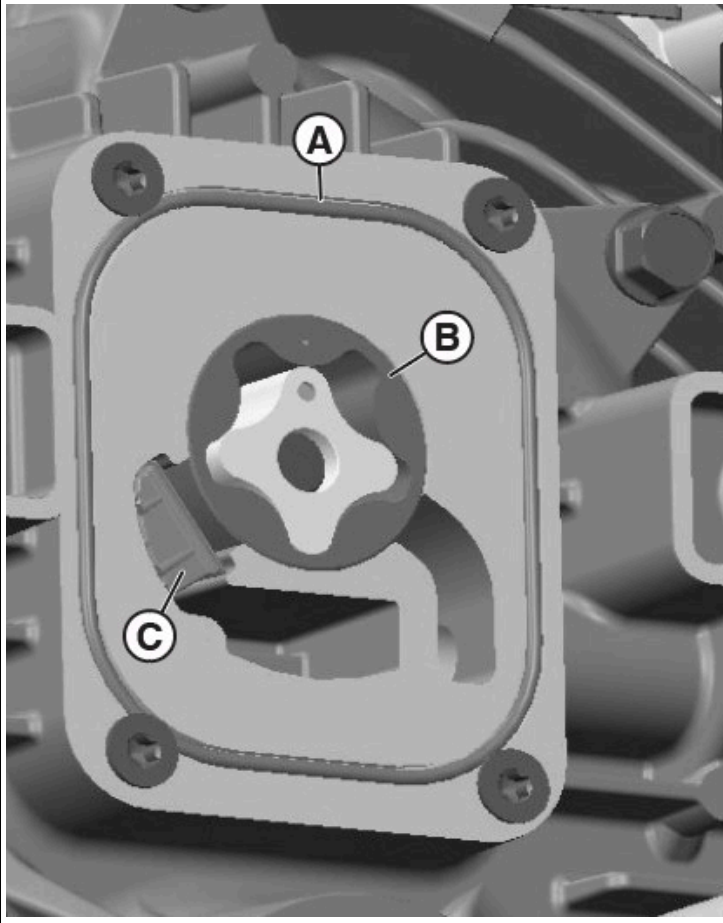
1. Remove 4 fasteners (A, Figure 139) to release oil scavenge pump gerotor cover (B) from the crankcase cover (C).

139



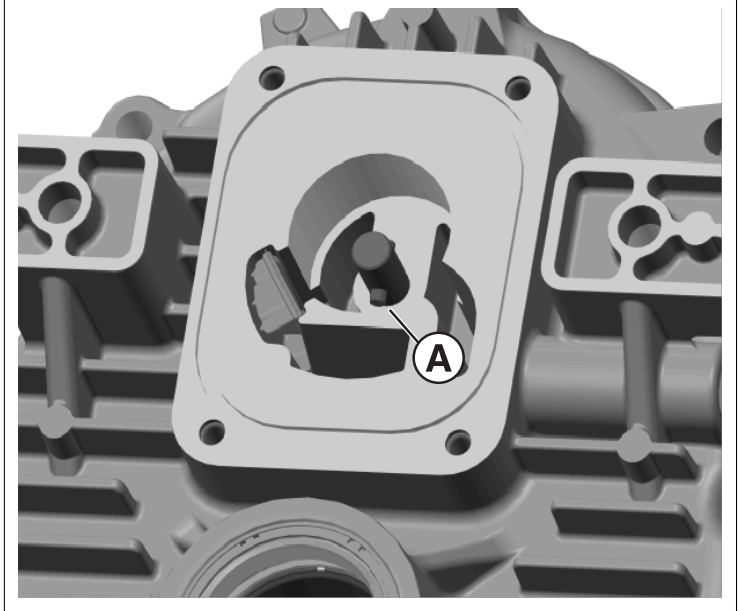
2. Remove o-ring (A, Figure 140) from the crankcase cover groove.

140



3. Remove inner and outer gerotors (B) from gear shaft.
4. Remove oil filter screen (C).
5. Remove roll pin (A, Figure 141) from hole in gear shaft.

141



6. On opposite side of crankcase cover, remove gear shaft assembly from crankcase cover.

Optional Oil Guard System - Assembly

Oil Guard Oil Scavenge Pump - Install

Using Figures 139, 140, 141 for reference, install the oil scavenge pump as follows:

1. Install the gear shaft assembly into the crankcase cover.
2. Install the roll pin into the hole in the gear shaft.
3. Install the oil filter screen.
4. Install the inner and outer gerotors onto the gear shaft.
5. Install **new** o-ring into the crankcase cover groove.
6. Install the oil pump cover onto the crankcase cover.
7. Start by hand the 4 cover fasteners. Tighten to **90 lb-in** (10.2 Nm).

Oil Guard Oil Supply Pump - Install

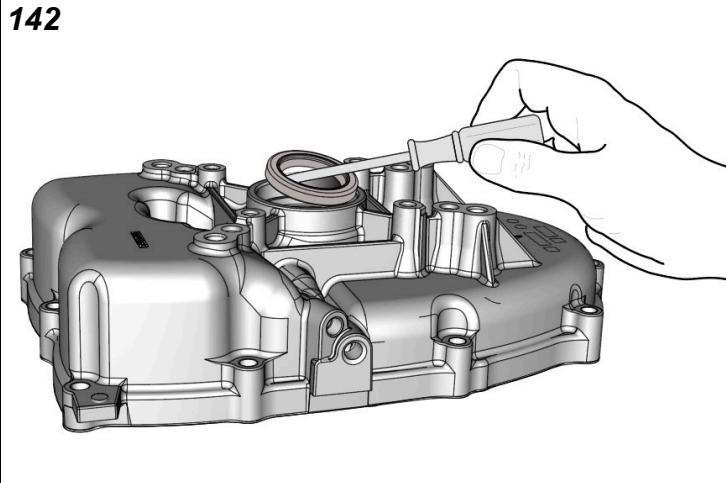
Using Figures 136, 137, and 138 for reference, install the oil supply pump as follows:

1. Install the gear shaft assembly into the crankcase cover.
2. Install the thrust washer onto the gear shaft on the opposite side of the crankcase cover.
3. Install the crescent ring onto the groove of the gear shaft.
4. Install the roll pin into the hole on the gear shaft.
5. Install the oil filter screen.
6. Install the inner and outer gerotors onto the gear shaft.
7. Install **new** o-ring into the crankcase cover groove.

8. Install the oil supply pump cover onto the crankcase cover.
9. Start by hand the 4 cover fasteners. Tighten to **90 lb-in** (10.2 Nm).

PTO Oil Bearing Seal - Disassembly

1. Using Figure 142 as a reference, remove and discard the oil seal from crankcase cover bearing bore, if present. Exercise care to avoid scratching bearing bore during removal.



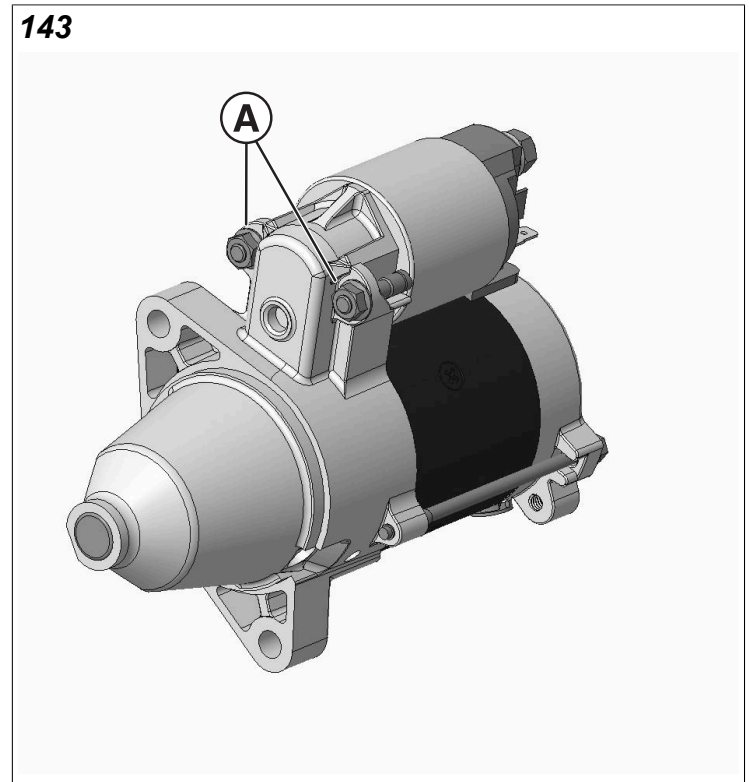
PTO Oil Bearing Seal - Assembly

1. Apply a thin film of clean engine oil the oil seal bore and OD of **new** oil seal.
2. Place the oil seal into the bearing bore.
3. Place the suitable oil seal driver on outside edge of oil seal.
4. Center oil seal driver under ram.
5. Slowly apply pressure to the oil seal driver until the oil seal is at a depth of **0.040-0.080 in** (1.0-2.0 mm) below the oil seal bore lip.

STARTER MOTOR

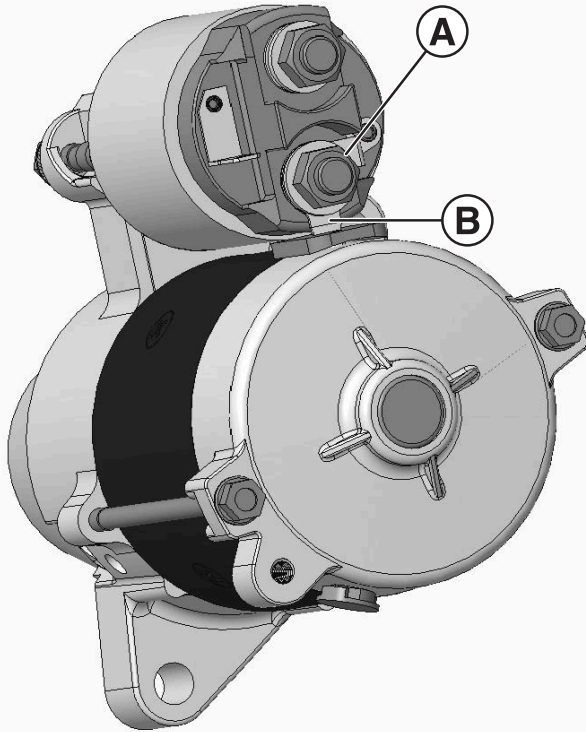
Starter Motor Solenoid - Disassembly

1. Remove the 2 solenoid mounting fasteners (**A**, Figure 143).



2. Remove the stator brush fastener and washer (**A**, Figure 144).

144



3. Disconnect the stator brush strap (**B**) from the solenoid by lifting it up and over the threaded stud. Take care to avoid damaging the brush strap.
4. Remove the solenoid from the starter motor housing.

Starter Motor Solenoid - Assembly

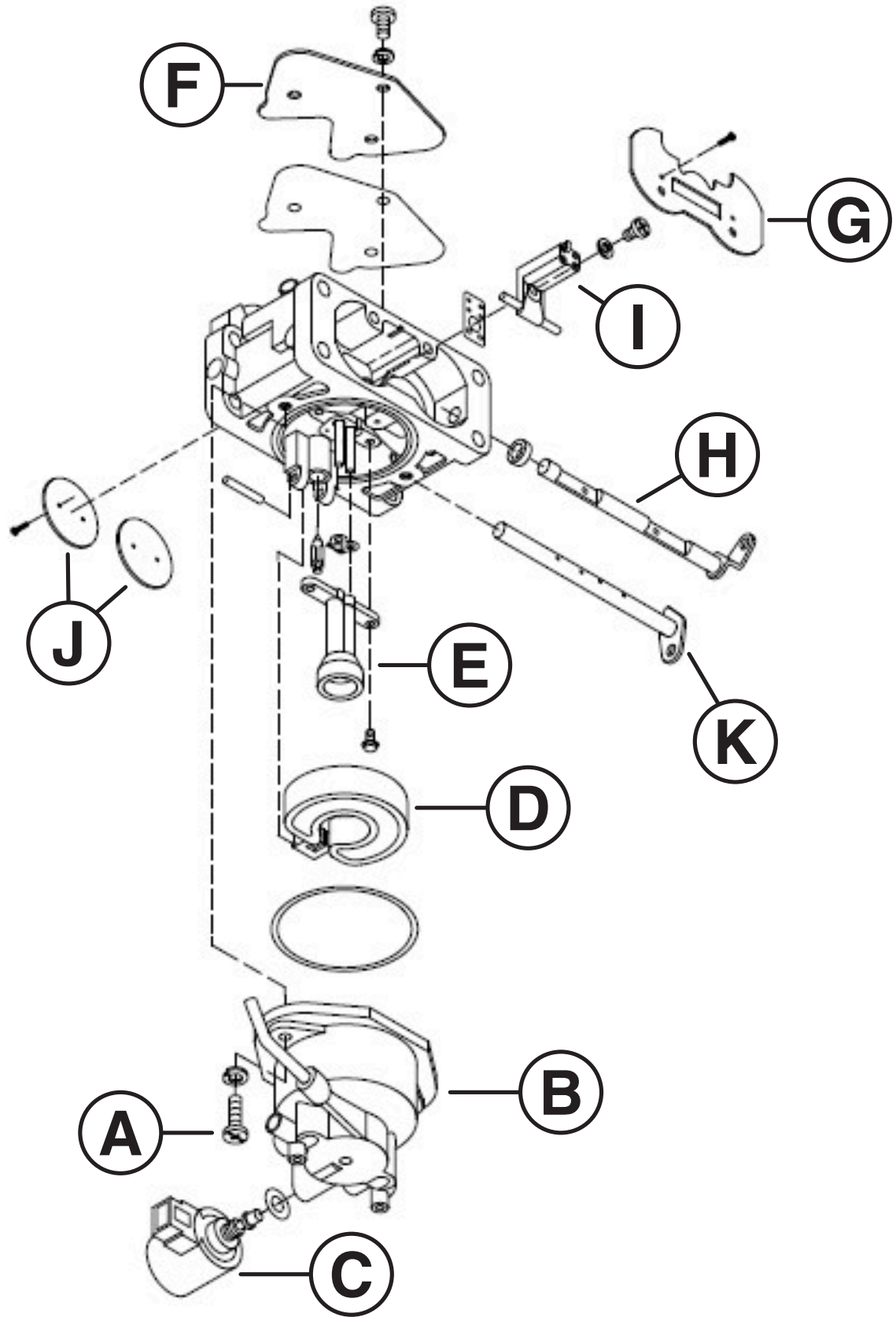
1. Apply grease (see *SECTION 9 - SPECIFICATIONS - Fluid and Sealant Specifications*) with a small brush or finger tip to the solenoid piston shaft.
2. Install the solenoid into the mounting fork of the starter motor.
3. Install the stator brush strap (**B**, Figure 144) over the lower mounting stud. Take care to not damage or break the strap.
4. Install the stator brush washer and fastener (**A**). Start by hand, then tighten to **87 lb-in** (9.8 Nm).
5. Install the 2 solenoid mounting fasteners (**A**, Figure 143). Start by hand, then tighten to **71 lb-in** (8 Nm).

EFI AND EFI-ETC SYSTEM

EFI and EFI-ETC System Components

The fuel system components on EFI and EFI-ETC equipped engines have limited serviceability.

1. Refer to the EFI and EFI-ETC Service and Diagnostic manual that applies to your engine.
2. Consult the *Illustrated Parts List* for the correct replacement parts.



Disassembly - Carburetor - Vanguard Model 540000

The Vanguard Model 540000 OHV V-Twin utilizes a fixed jet, two-barrel, side draft, flo-jet carburetor. Except for idle speed, the carburetor is non adjustable. The carburetor incorporates a fuel shut-off (anti-afterfire) solenoid that controls the flow to the fuel metering system. The solenoid is controlled by the ignition switch.

1. Remove the 2 float bowl fasteners (**A**, Figure 145).
Remove the float bowl (**B**) and discard the o-ring.

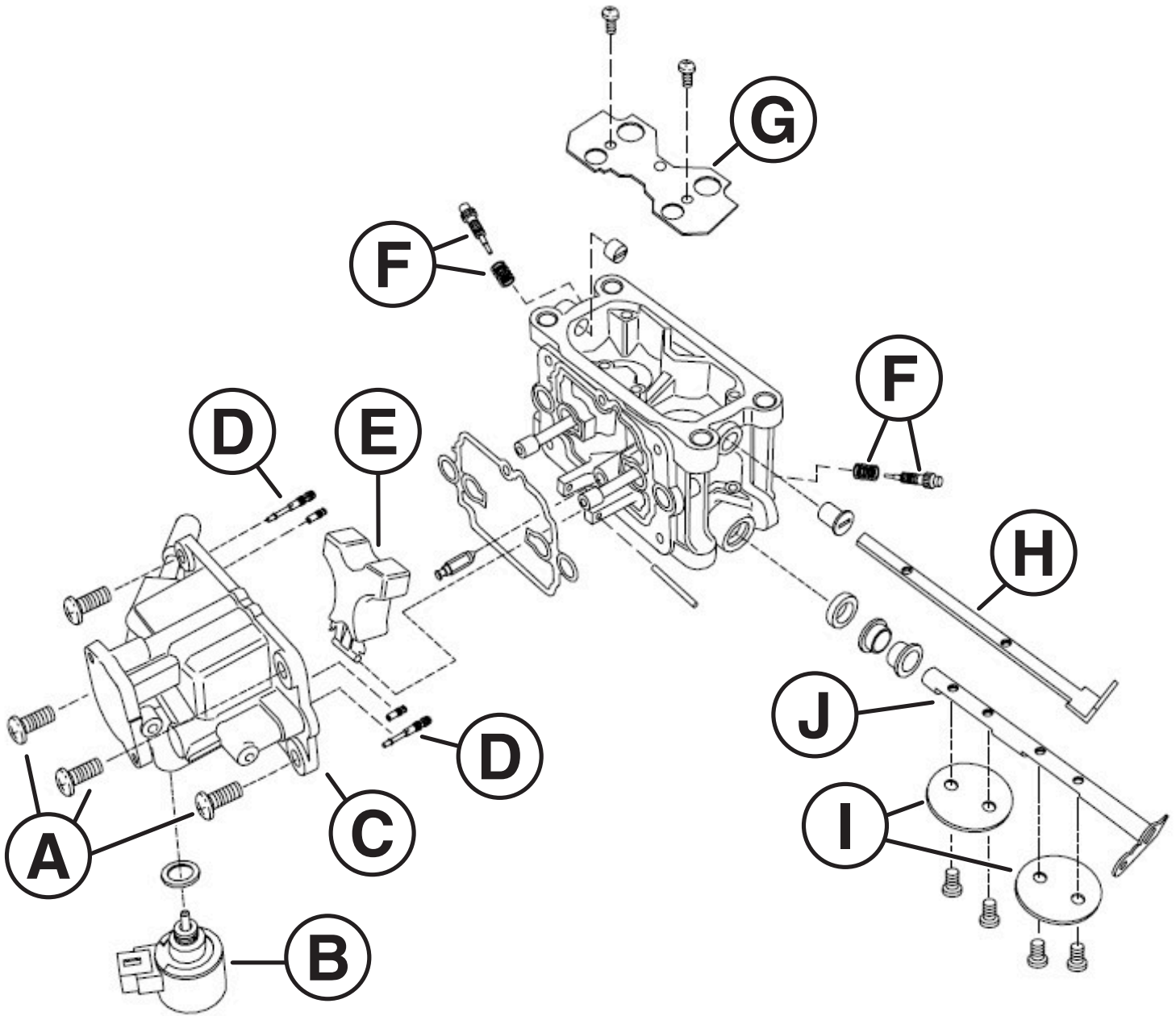
NOTE: The carburetor and float bowl may contain residual gasoline. Drain any remaining gasoline into an approved container and thoroughly wipe up any spilt fuel immediately.

2. Using a thin profile wrench, remove the anti-afterfire solenoid (**C**) from the float bowl. Discard gasket ring.

NOTE: Care must be taken when removing the anti-afterfire solenoid to prevent damage to the fixed main jet and housing.

3. Remove the main jet from the carburetor body.
4. Remove the float hinge pin, float (**D**) and needle.
5. Remove the emulsion tube body fastener and remove the emulsion tube (**E**) and gasket. Discard old gasket.

6. Remove the 3 fasteners that secure the cover plate (**F**) to the carburetor body. Remove the cover plate and discard the gasket.
7. Remove the 2 fasteners that secure the choke plate (**G**) to the choke shaft (**H**). Remove the choke plate and set aside.
8. Remove the circlip and washer from the end of the choke shaft, external to the carburetor body.
9. Remove the choke shaft from the carburetor body and discard the seal.
10. Remove the fastener that secures the nozzle body (**I**) to the carburetor. Remove the nozzle body and discard the gasket.
11. Mark the throttle plates (**J**) before removal so that they can be re-installed in the original position. The sides of the throttle plates are beveled.
12. Remove the fasteners that secure the throttle plates to the throttle shaft (**K**). Remove throttle plates and set aside.
13. Remove the circlip and washer from the end of the throttle shaft, external to the carburetor body.
14. Remove the throttle shaft from the carburetor body. Discard seal.



Disassembly - Carburetor - Vanguard Model 610000

The Vanguard Model 610000 OHV V-Twin utilizes a fixed jet, two-barrel, side draft, flo-jet carburetor. Except for idle speed, the carburetor is non adjustable. The carburetor incorporates a fuel shut-off (anti-afterfire) solenoid that controls the flow to the fuel metering system. The solenoid is controlled by the ignition switch.

1. Remove the 4 float bowl fasteners (**A**, Figure 146) and remove the float bowl (**B**) and gasket. Discard gasket.
2. Using a thin profile wrench, remove the anti-afterfire solenoid (**C**) from the float bowl. Discard sealing washer.
3. Remove the main jets (**D**) from the float bowl.
4. Remove the float hinge pin, float (**E**), and needle from the carburetor body.
5. Remove the limiter caps and mixture adjustment screw (**F**) from both sides of the carburetor.
6. Remove the choke plate fasteners and choke plate (**G**).
7. Remove the circlip and washer that secure the choke shaft to the carburetor. Remove the choke shaft (**H**) and bushings from the carburetor.
8. Mark the throttle plates (**I**) before removal so they can be re-installed in the original position.
9. Remove the throttle plate fasteners and throttle plates.
10. Remove the circlip and washer that secure the throttle shaft (**J**) to the carburetor. Remove the throttle shaft, bushings, and seal from the carburetor. Discard seal.

Cleaning and Inspection - Carburetor

1. Obtain Carburetor Cleaner.
NOTE: Remove and set aside all rubber parts or those that have rubber components, such as the needle valve, O-rings, and fuel hose, as these can be damaged by the carburetor cleaner.
2. Inspect carburetor body and float bowl for sediment, gum or varnish deposits. Spray parts and then wipe away cleaning solution with a clean cloth. Repeat step until clean cloth shows no evidence of dirt or debris.
3. Inspect carburetor body and float bowl for cracks or other damage. Replace carburetor if either condition is observed.
4. Locate each fuel and air passageway in the carburetor body. Look for the brass or bronze beads in the casting, which point out where the cross drillings of the passageways are located.
5. Spray carburetor cleaner into the entrance of each passageway and look for the solution to exit from one or more passageways.
6. Use carburetor cleaner and compressed air to ensure that each passageway is clean and open.
NOTE: Avoid use of wires or pointed tools as they can scratch or damage surfaces, enlarge holes, and push grit and dirt deeper into carburetor.
7. Look through the main jet while holding it up to the light. The hole should appear round and unobstructed. Thoroughly clean with carburetor cleaner and compressed air.
8. Hold main jet assembly up to the light to verify cleanliness. Verify that all orifices are clean and open.
9. Check main jet passageway for discoloration, dirt, and debris. Clean passageway with a soft bristle gum cleaning brush.
10. Use compressed air to clean atmospheric vent holes and air/fuel jets embedded in the carburetor body.
11. Inspect the needle valve and seat. Check tip of needle valve for wear or grooves. Replace parts as necessary.
12. Inspect float for distortion, dents, cracks, or holes. Submerge float in a glass of water to verify that it is water tight. Replace float if damaged or if it cannot be adequately cleaned.
13. Spray choke shaft and valve and then wipe using a clean cloth. Inspect for damage or wear.
14. Spray throttle shaft and valve and then wipe using a clean cloth. Inspect for damage or wear.
15. Thoroughly dry all parts with compressed air.

Assembly - Carburetor Vanguard Model 540000

1. Install **new** seals onto the throttle shaft (**K**, Figure 145). Install throttle shaft into the carburetor body.
2. Install the throttle shaft washer and circlip to secure the throttle shaft to the carburetor.

3. Apply LOCTITE 222, or equivalent, on throttle plate fastener threads. Install one throttle plate (**J**) at a time. Check throttle for freedom of operation before installing the other throttle plate. Tighten throttle plate fasteners until snug.
4. Install carburetor cover plate (**F**) with **new** gasket. Tighten fasteners until snug.
5. Install the nozzle body (**I**) with **new** gasket into the carburetor. Install the nozzle fastener and tighten until snug.
6. Install **new** choke shaft seal onto the choke shaft (**H**). Install choke shaft into the carburetor body.
7. Install the choke shaft washer and circlip to secure the choke shaft to the carburetor.
8. Apply LOCTITE 222, or equivalent, on choke plate fastener threads. Install the choke plate (**G**) onto the choke shaft. Install fasteners and tighten until snug.
9. Install the emulsion tube body (**E**) with **new** gasket. Install the fastener and tighten until snug.
10. Assemble the needle to the float (**D**) and install the float onto the carburetor securing it with the hinge pin.
11. Install the anti-afterfire solenoid (**C**) with **new** gasket ring into the float bowl (**B**). Using a thin profile wrench tighten the solenoid until snug.

NOTE: DO NOT overtighten the anti-afterfire solenoid. Damage to the main jet and float bowl may occur.

12. Install the float bowl with **new** o-ring onto the carburetor. Install the 2 float bowl fasteners and tighten until snug.

Assembly - Carburetor - Vanguard Model 610000

1. Install **new** seal and bushings onto throttle shaft (**J**, Figure 146). Install throttle shaft into carburetor body.
2. Install the throttle shaft washer and circlip to secure the throttle shaft to the carburetor.
3. Apply LOCTITE 222, or equivalent, on throttle plate fastener threads. Install one throttle plate (**I**) at a time. Check throttle for freedom of operation before installing the other throttle plate. Tighten throttle plate fasteners until snug.
4. Install bushings onto choke shaft (**H**). Install choke shaft into carburetor body.
5. Install the choke shaft washer and circlip to secure the choke shaft to the carburetor.
6. Apply LOCTITE 222, or equivalent, on choke plate fastener threads. Install the choke plate (**G**) onto the choke shaft. Install fasteners and tighten until snug.
7. Install the mixture adjustment screws and limiter caps (**F**) into the carburetor body.
8. Assemble the needle to the float (**E**) and install the float onto the carburetor securing it with the hinge pin.
9. Install the main jets (**D**) into the float bowl (**B**).
10. Install **new** float bowl gasket onto the carburetor body.

11. Using a thin profile wrench, install the anti-afterfire solenoid into the float bowl with **new** sealing washer. Tighten until snug.
12. Install the float bowl and 4 fasteners (**A**) onto the carburetor body. Tighten until snug.

NOTE: DO NOT overtighten the anti-afterfire solenoid. Damage to the main jet and float bowl may occur.

MIXER - GASEOUS ENGINES

Mixer - Gaseous Engines

The mixer on gaseous engines cannot be overhauled.

NOTE: Always have a certified LPG/NG technician perform repairs on gaseous fuel systems.

Consult the *Illustrated Parts List* to obtain the correct replacement mixer, spacers, and gaskets.

SECTION 7 - ASSEMBLE ENGINE

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Top End Assembly	126
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Preliminary Instructions

Prior to starting any repair or maintenance operation. Make sure you are familiar with ALL safety warnings and procedures as outlined in *SECTION 1 - SAFETY AND GENERAL INFORMATION - Safety Information*.

ALWAYS wear safety glasses and gloves while performing any maintenance and repair operation.

BOTOM END ASSEMBLY

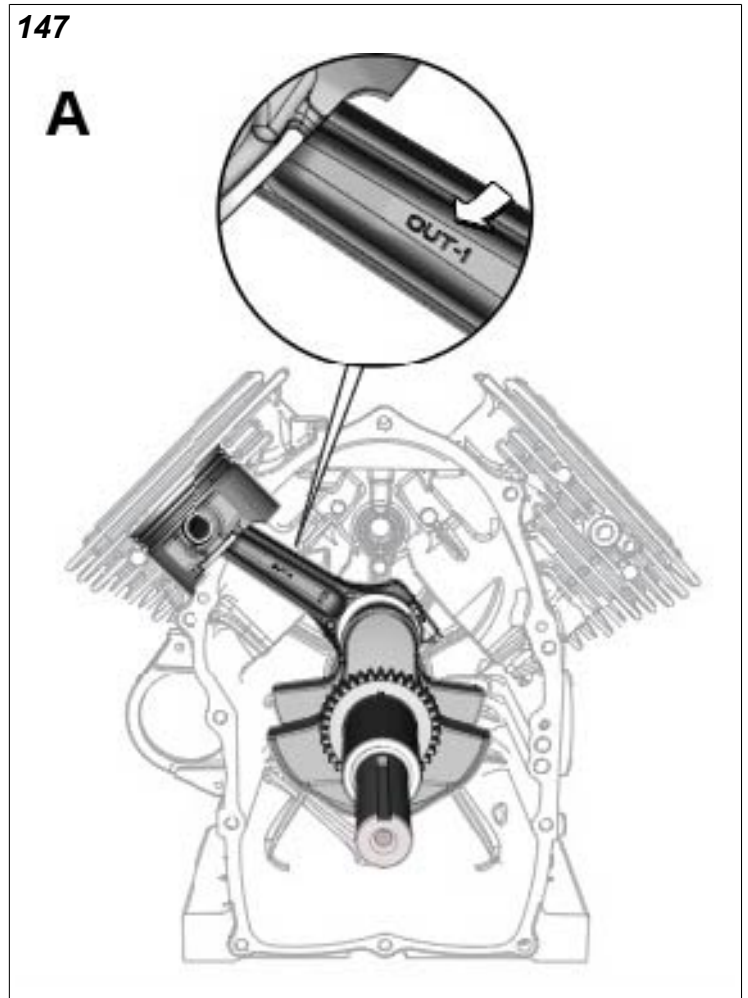
Bottom End Assembly

1. Apply a thin film of clean engine oil to MAG bearing oil seal lip.
2. Verify end play shims are installed on crankshaft, if used.
3. Thoroughly lubricate crankshaft MAG bearing journal and PTO bearing journal with clean engine oil.
4. Lubricate crank pin with General Lithium Grease.
5. Install oil seal protector sleeve over crankshaft taper.

NOTE: Use black electrical tape if oil seal protector sleeve is not available.

6. Carefully install crankshaft into crankcase positioning MAG bearing journal in MAG bearing.
7. Remove oil seal protector sleeve (or black electrical tape) from crankshaft taper.
8. Rotate crankshaft until crank pin journal is at the bottom of its stroke.
9. Verify that piston ring end gaps are properly staggered. See *SECTION 6 - SERVICE ENGINE SUBASSEMBLIES - PISTON AND CONNECTING ROD - Assembly*.

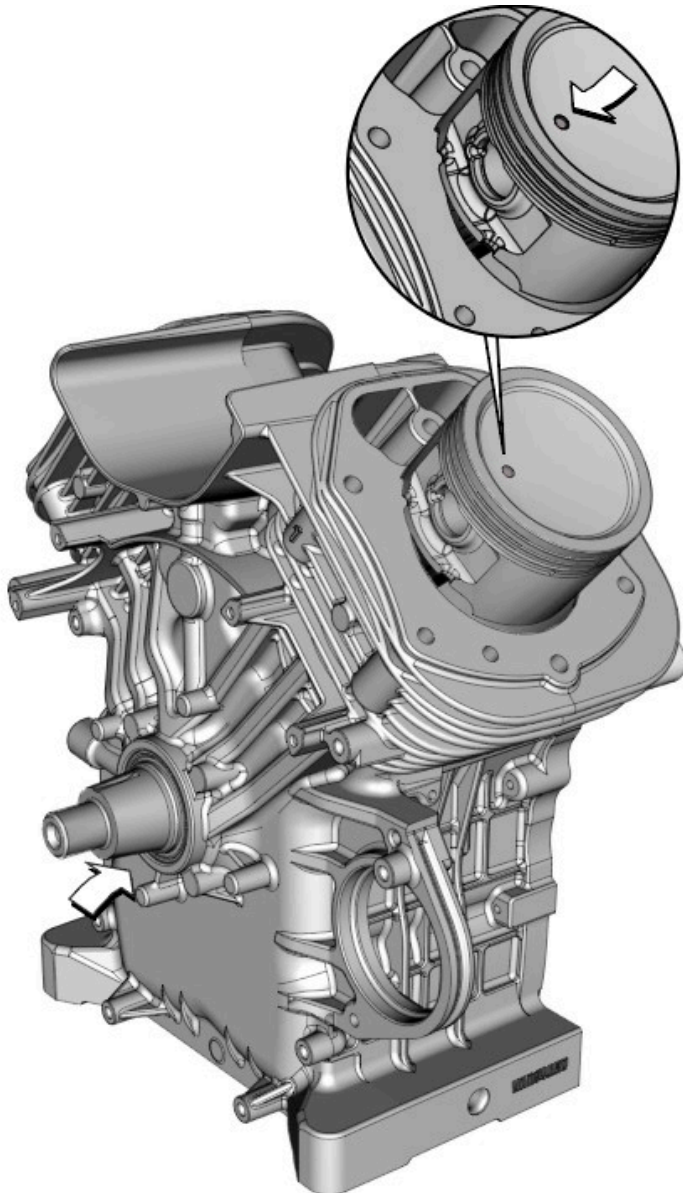
10. Start piston/connecting rod assembly into bore of cylinder 1, so that the rod stamp **OUT-1** is visible through the crankcase cover opening (**A**, Figure 147).



NOTE: While the crankcase is stamped with the numbers 1 and 2 to identify cylinder location, it may be easier to remember that cylinder 1 is always on the starter motor mount side.

11. See Figure 148. Verify that the locating dot on the piston crown is on the MAG bearing side.

148



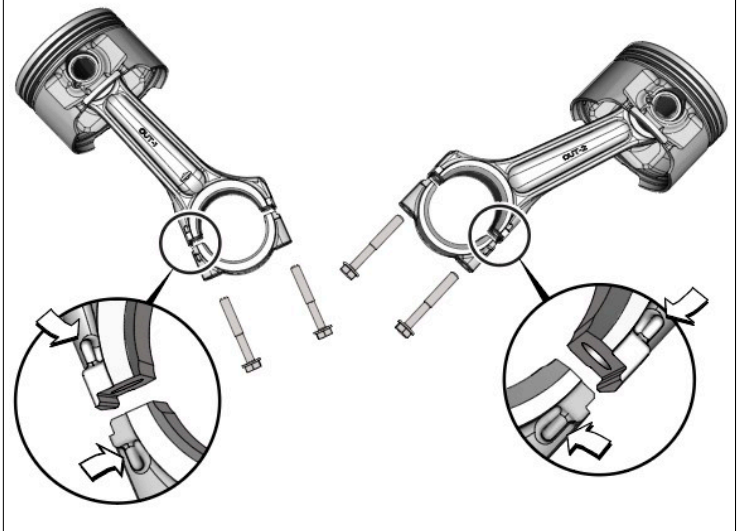
12. Obtain the Piston Ring Compressor (see *SECTION 3 - TROUBLESHOOTING - Special Tool List*), and proceed as follows:

- A. Using tool wrench, unwind sleeve of piston ring compressor. Do not unwind sleeve too far or tool damage will occur.
- B. Apply clean engine oil to piston rings, piston skirt, cylinder bore, and inside wall of Piston Ring Compressor.
- C. Slide compressor sleeve over piston, and using tool wrench, tighten to compress piston rings into piston ring grooves.
- D. Verify that all piston rings are captured and compressed, but that compressor sleeve is still loose enough to be rotated.
- E. Gently tap on the top edge of the compressor sleeve to be sure the bottom edge is in full contact with cylinder deck.
- F. Apply steady pressure to piston crown to slide piston from compressor sleeve into cylinder bore.

NOTE: Do not hammer piston into cylinder bore or piston rings may be damaged. If piston travel is stopped before it completely enters the cylinder bore, then retract the piston, reset the piston ring compressor sleeve, and try again.

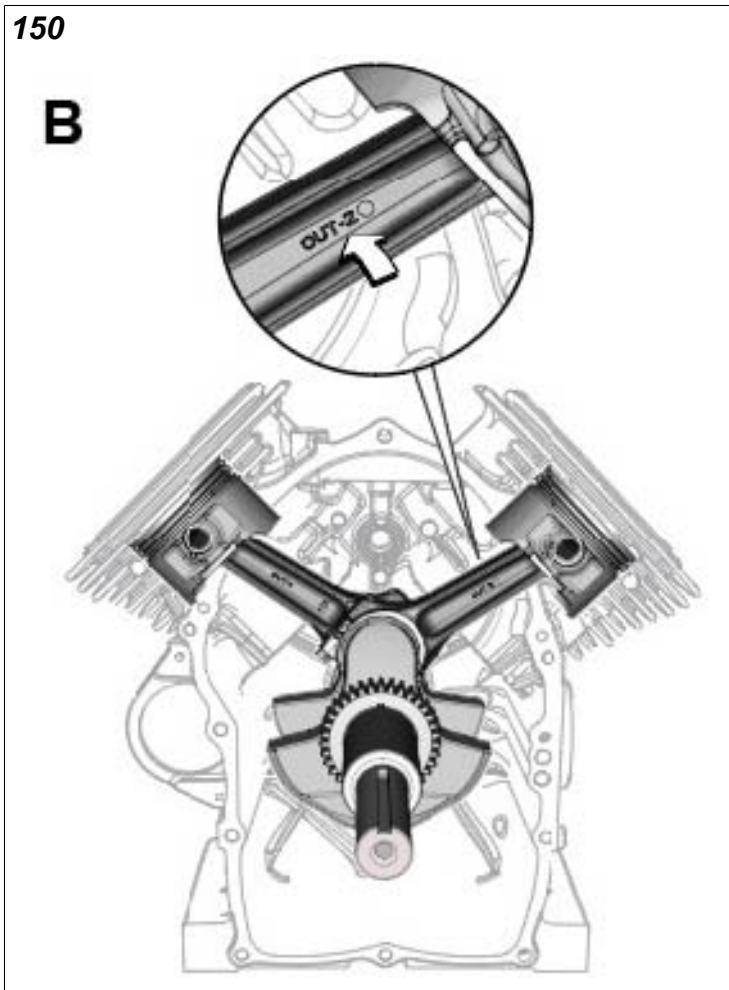
13. See Figure 149. With connecting rod positioned on crank pin journal, install connecting rod cap, so that the match marks on cap and connecting rod are aligned.

149



14. Start the 2 fasteners to secure the connecting rod cap to the connecting rod. Starting with the bolt closest to the piston, tighten screws to **130 lb-in (14.7 Nm)**.

15. Start piston/connecting rod assembly into cylinder 2 bore, so that the rod stamp **OUT-2** is visible through the crankcase cover opening (**B**, Figure 150), and the locating dot on the piston crown is on the MAG bearing side. Repeat steps 13-17.



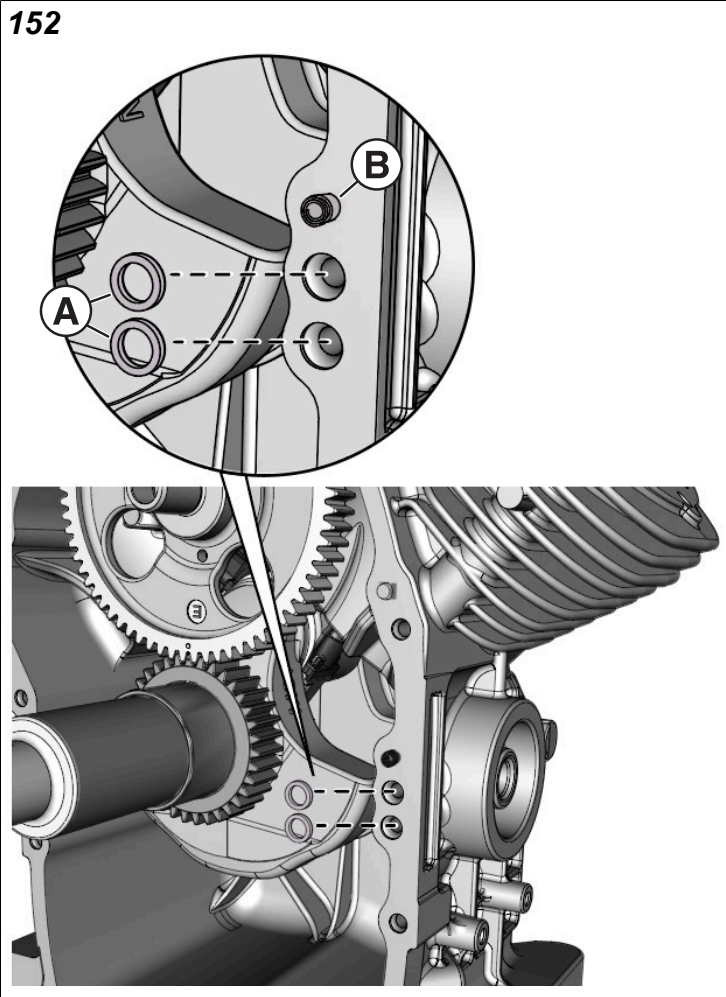
16. Rotate crankshaft two revolutions to be sure crankshaft, connecting rods, and pistons move freely without binding.
17. Move connecting rods sideways to verify clearance on each side of crank pin journals.
18. Thoroughly lubricate tappet bores and tappet shafts with clean engine oil.
19. Install tappets into tappet bores. Be sure to install each tappet in the same bore from which it was removed.
20. Lubricate the camshaft MAG bearing journal, camshaft lobes, and camshaft bearing bore in crankcase with clean engine oil.

21. Verify that valve tappets are clear of camshaft lobes, and install camshaft into bearing bore aligning timing mark on camshaft gear root with timing mark on crankshaft gear tooth. See Figure 151.



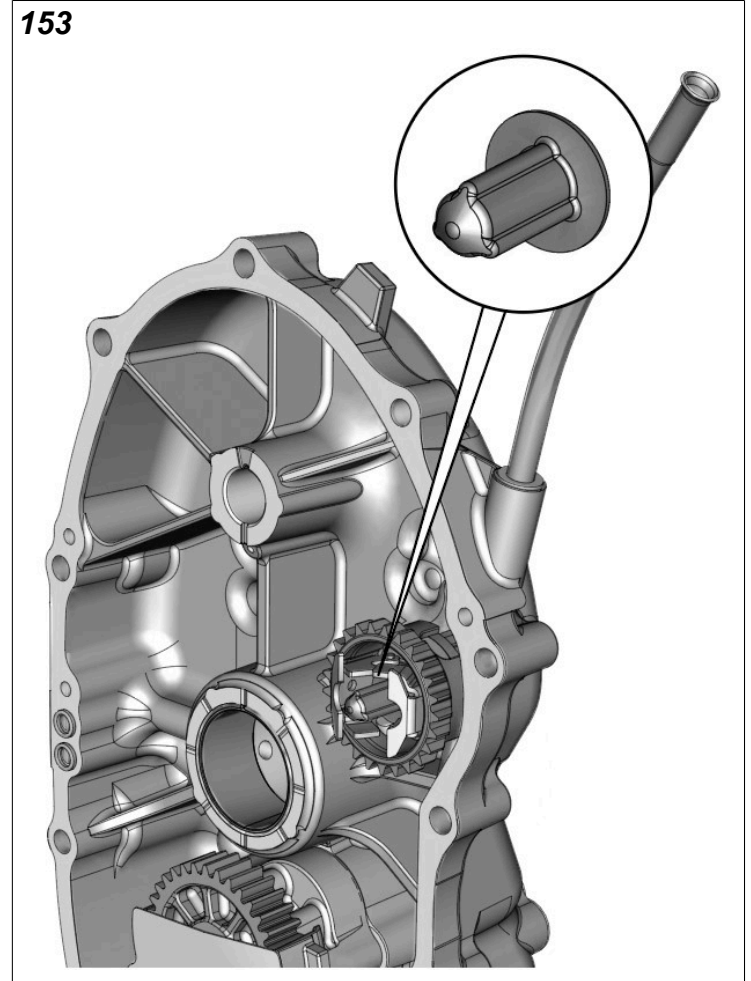
22. Lubricate the camshaft and crankshaft gear mesh with clean engine oil.
23. Verify that mating surfaces of crankcase and crankcase cover are clean and dry. Any dust or dirt left on mating surfaces can cause leaks.

24. Lightly lubricate two **new** o-rings (A, Figure 152) with clean engine oil and insert into crankcase flange. Be sure that old o-rings are not installed, as stacking old and new o-rings will cause oil leaks.



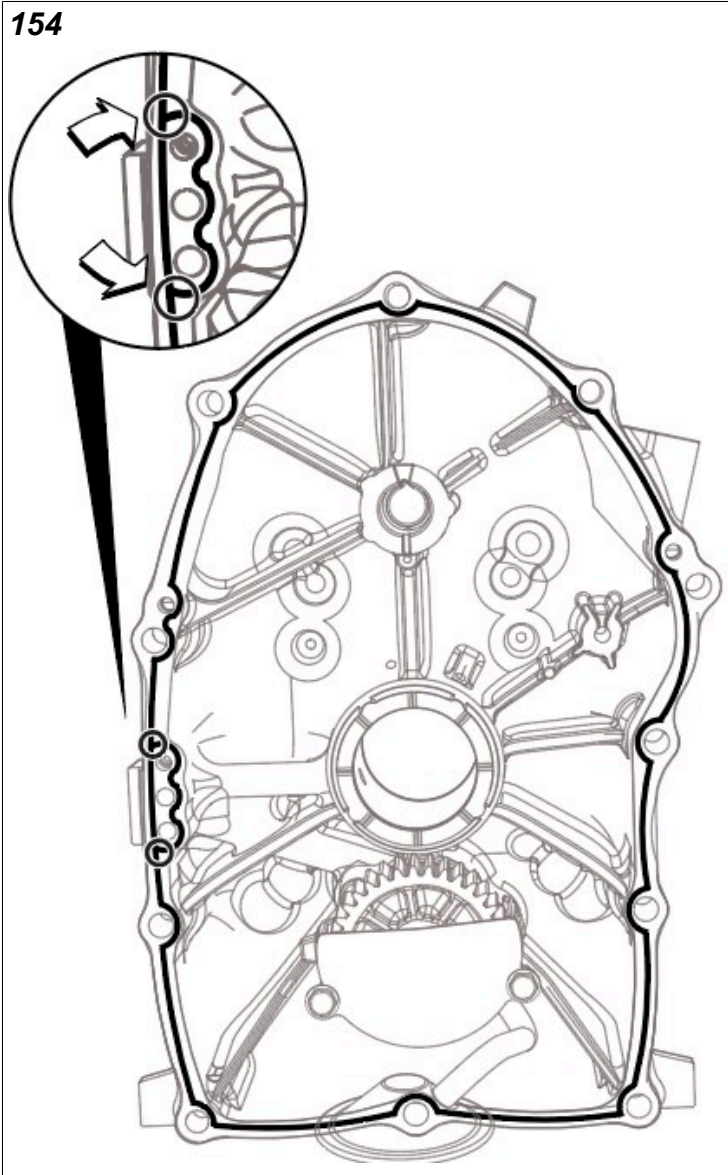
25. Lubricate the camshaft PTO bearing journal, and camshaft bearing bore in crankcase cover with clean engine oil.
26. Apply a thin film of clean engine oil to PTO bearing oil seal lip.

27. See Figure 153. Verify that governor cup is installed on governor gear shaft.



28. Verify two locating pins are present on crankcase flange. Install **new** locating pins if damaged or missing.

29. See Figure 154. Install steel core gasket, if used, or apply a bead of Silicone Sealant (see *SECTION 9 - SPECIFICATIONS - Lubricants and Sealants*) **0.06-0.10 inches** (1.5-2.5 mm) thick to crankcase cover. Bead must be a continuous closed loop with no gaps and an overlap not exceeding **0.20 inches** (5 mm) in the two areas shown.



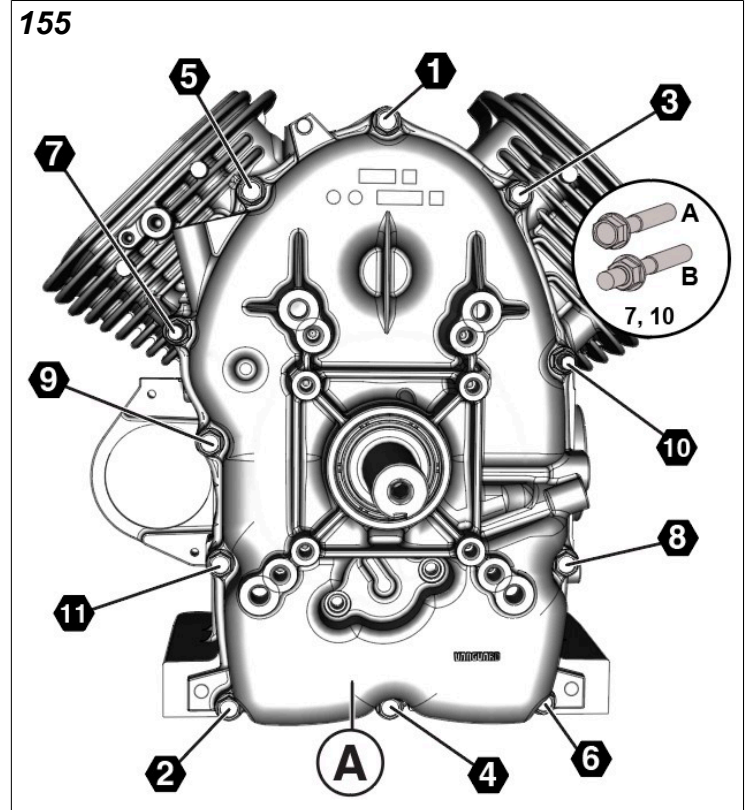
NOTE: Crankcase cover must be installed within five minutes of application. If time limit is exceeded, scrape off silicone sealant and reapply.

30. Install oil seal protector sleeve on crankshaft.

NOTE: Use black electrical tape if oil seal protector sleeve is not available.

31. Install crankcase cover onto 2 locating pins.
32. Remove oil seal protector sleeve (or black electrical tape) from crankshaft.

33. Start 11 fasteners to secure crankcase cover (A, Figure 155) to crankcase. Proceed as follows:



NOTE: See inset of Figure 155. In lieu of the standard screw in positions 7 and 10, install the threaded stud, if equipped with the optional muffler bracket support.

NOTE: Verify cleanliness of crankcase cover screws. Friction caused by dirt and debris will result in a false torque reading.

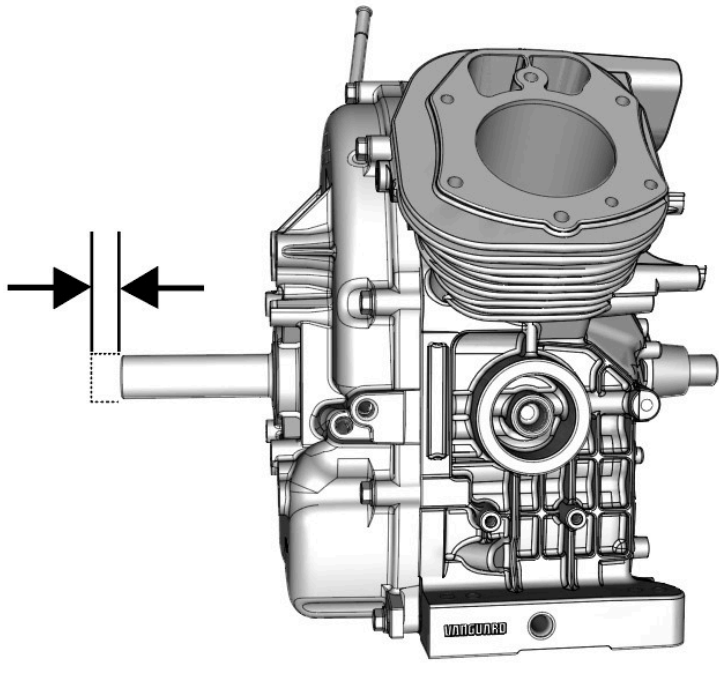
- A. Tighten bolts to **65 lb-in** (7.3 Nm) using the sequence shown in Figure 155.
- B. Tighten bolts to **130 lb-in** (14.7 Nm) using the sequence shown.
- C. Final tighten bolts to **195 lb-in** (22 Nm) using the sequence shown.

NOTE: Failure to step-torque bolts in the proper sequence may result in gasket leaks or cause the crankcase cover to warp.

34. Rotate crankshaft to check for binding.

35. Using Figure 156 as a reference, check crankshaft end play as follows:

156

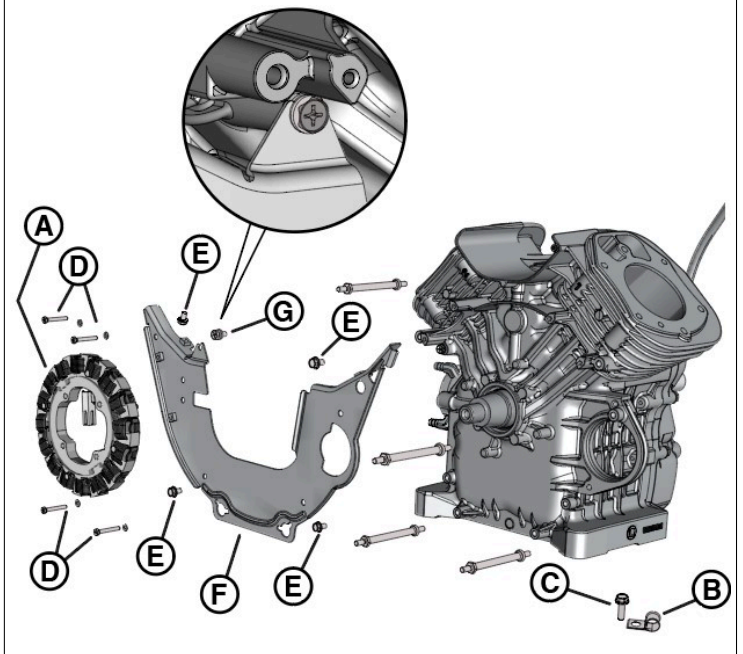


- A. Mount base of dial indicator to crankcase or crankcase cover.
- B. Set the indicator contact point on the end of the crankshaft.
- C. Firmly push opposite end of crankshaft as far as it will go while rotating it back and forth.
- D. While still pushing on crankshaft, zero dial indicator gauge.
- E. Firmly pull crankshaft as far as it will go while rotating it back and forth.
- F. While still pulling on crankshaft, note the reading of the dial indicator gauge.
- G. Verify that end play is **0.004-0.017 inches** (0.09-0.44 mm) if Silicone Sealant bead was applied to crankcase cover, or **0.015-0.039 inches** (0.39-1.00 mm) if steel core gasket was installed.
- H. Repeat the procedure to verify the reading.
- I. If end play is not within specification, replace the crankcase cover. If engine is used in a pump application, remove crankcase cover and add or remove shims as necessary.

Alternator and Guard Plate

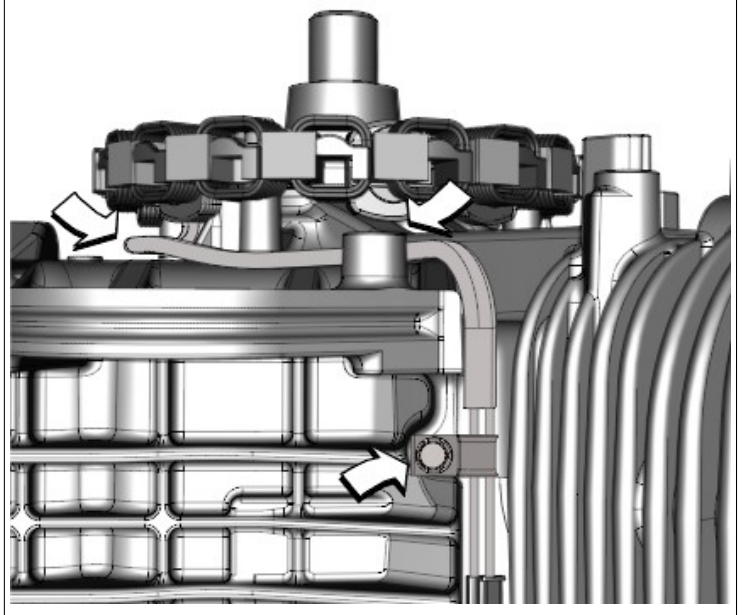
1. Place the stator (A, Figure 157) on crankcase bosses.

157



2. Route stator wires around the boss as shown in Figure 158.

158



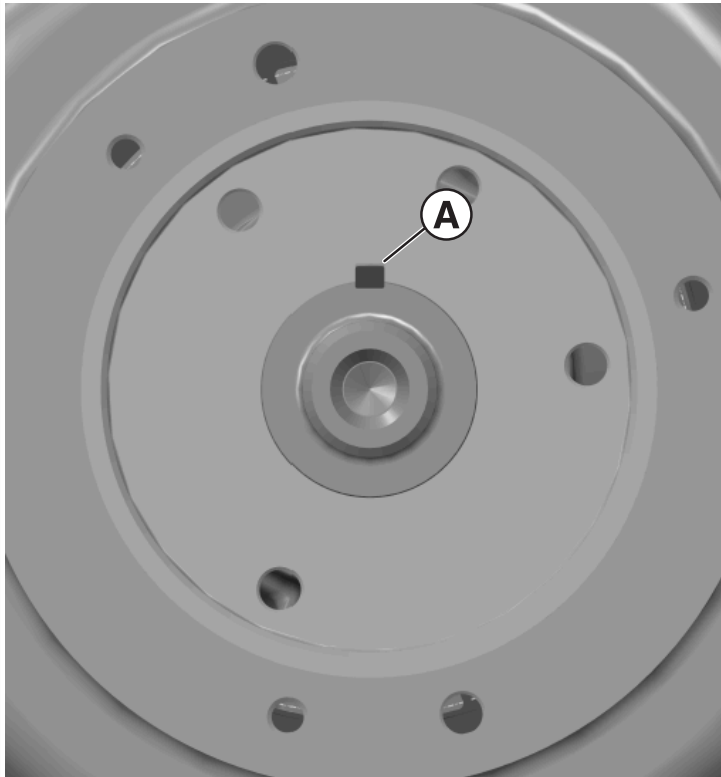
3. Capture stator wires in clamp (B, Figure 157) and start screw (C) to fasten clamp to crankcase. Tighten fastener to **90 lb-in** (10.2 Nm). Sleeve does not need to be captured in clamp.
4. Install 4 fasteners with flat washers (D) to fasten stator to crankcase. Alternately tighten fasteners to **30 lb-in** (3.4 Nm) using a crosswise pattern.
5. Install 4 fasteners (E) to fasten back plate (F) to crankcase. Tighten fasteners to **90 lb-in** (10.2 Nm).

6. Install SEMS screw (**G**) to fasten back plate to crankcase at location shown. Tighten fastener to **90 lb-in** (10.2 Nm).

Flywheel Fan and Flywheel

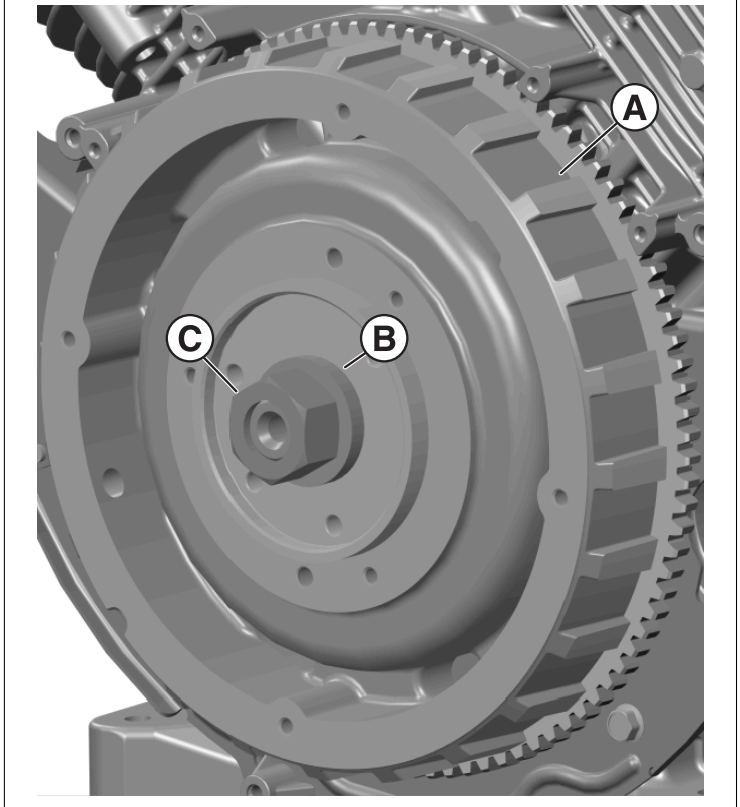
1. Verify that flywheel and crankshaft tapers are free of grease, oil, dust, and dirt. Verify that keyways are clean and completely free of dirt and grit.
2. Install key (**A**, Figure 159) into keyway on crankshaft taper.

159



3. Install flywheel (**A**, Figure 160) engaging keyway with installed key on crankshaft taper. Verify that flywheel fits tightly without wobbling.

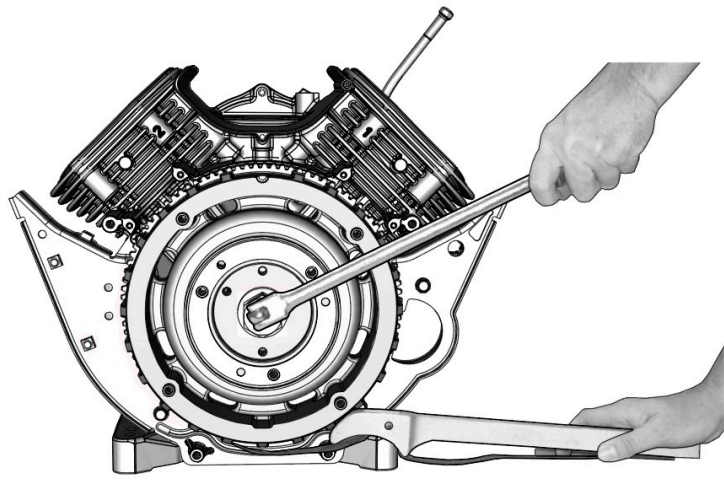
160



4. Install flat washer (**B**) and flywheel nut (**C**). Orient washer with the flat side facing the nut. Hand tighten flywheel nut.

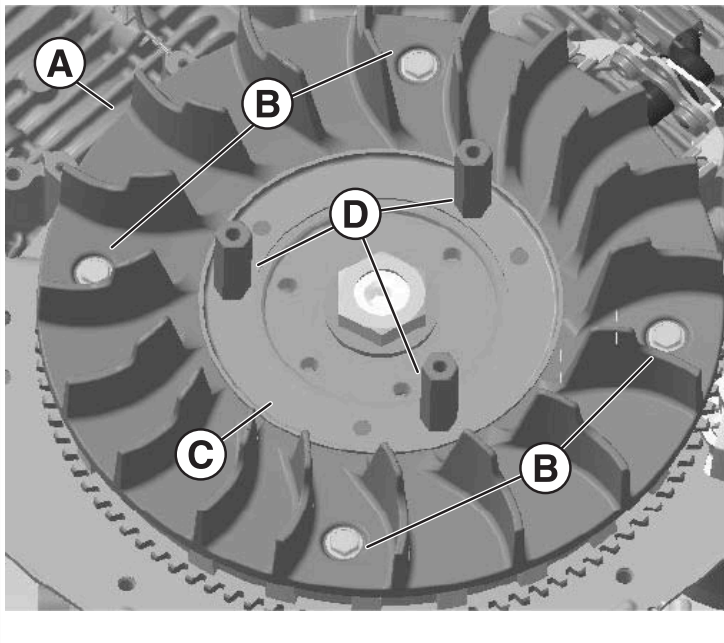
- Obtain Strap Wrench (see *SECTION 3 - TROUBLESHOOTING - Special Tool List*), torque wrench, and correct size socket. Using Figure 161 as a reference, proceed as follows:

161



- Fit loop of strap around flywheel and tighten until snug.
 - Pinch strap between heel of wrench and flywheel.
 - Holding tool down by the handle, tighten flywheel nut to **121 lb-ft (163.8 Nm)**.
 - Remove strap wrench from flywheel.
- Install fan (A, Figure 162) on flywheel and start 4 fasteners by hand (B). Alternately tighten fasteners to **90 lb-in (10.2 Nm)** using a crosswise pattern.

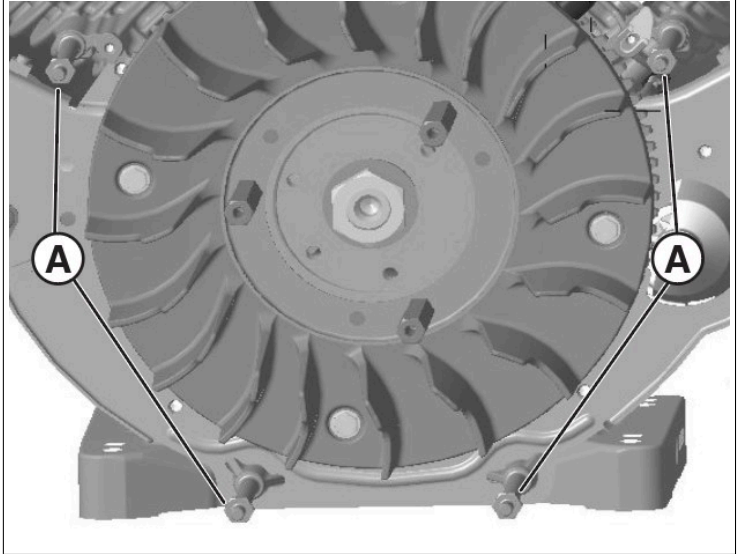
162



- Install fan ring (C) onto flywheel. Install 3 rotating fan studs (D) and tighten to **100 lb-in (11.3 Nm)**.

- Install 4 blower housing mounting posts (A, Figure 163) into crankcase. Tighten posts to **110 lb-in (12.4 Nm)**.

163



- See *TOP END ASSEMBLY* in this section.

TOP END ASSEMBLY

Top End Assembly

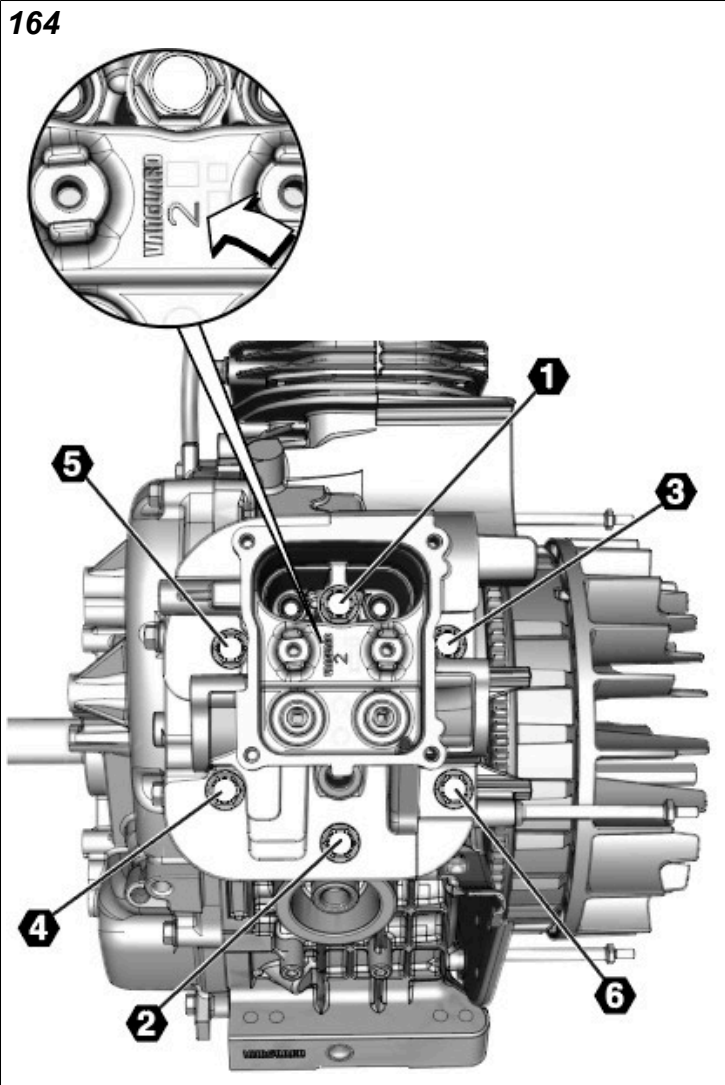
- Verify that mating surfaces of cylinder and cylinder head are clean and dry. Any dust or dirt left on mating surfaces can cause leaks.
- Verify that 2 locating pins are present on downside of cylinder deck. Install **new** locating pins if damaged or missing.
- Install **new** cylinder head gasket onto locating pins.
- Install cylinder head onto locating pins.

NOTE: Cylinder heads are stamped with the numbers 1 and 2 to identify proper location. See example in the inset of Figure 164. While the crankcase is also stamped, it may be easier to remember that cylinder 1 is on the starter motor mount side and cylinder 2 is on the oil filter mount side.

- Start the 6 cylinder head bolts and hand tighten until snug.

NOTE: Verify cleanliness of cylinder head bolts. All cylinder head bolts must be clean, dry and free from contamination prior to installation. Friction caused by dirt will result in a false torque reading.

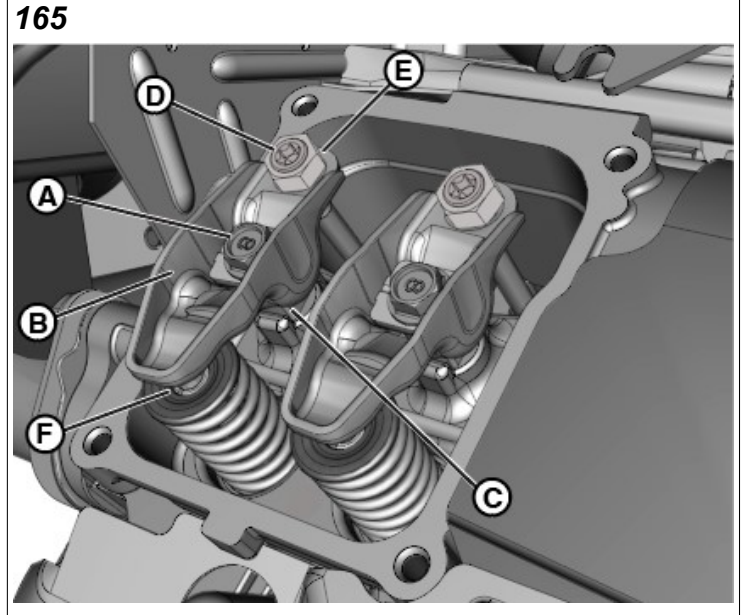
- Tighten cylinder head bolts in sequence as shown in Figure 164:



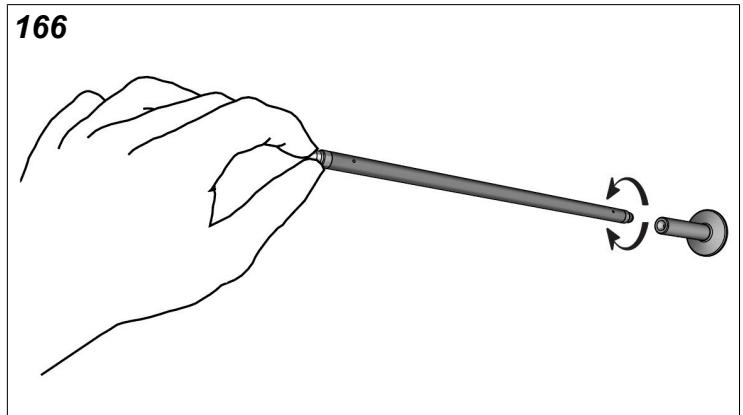
- Tighten bolts to **116 lb-in** (13.1 Nm) using the sequence shown.
- Tighten bolts to **232 lb-in** (26.2 Nm) using the sequence shown.
- Final tighten bolts to **348 lb-in** (39.3 Nm) using the sequence shown.

NOTE: Failure to step-torque cylinder head bolts in the proper sequence may result in gasket leaks or cause the cylinder head to warp.

- Start fasteners (**A**, Figure 165) to fasten rocker arms (**B**) and fulcrums (**C**) to cylinder head. Tighten fasteners to **105 lb-in** (11.9 Nm).



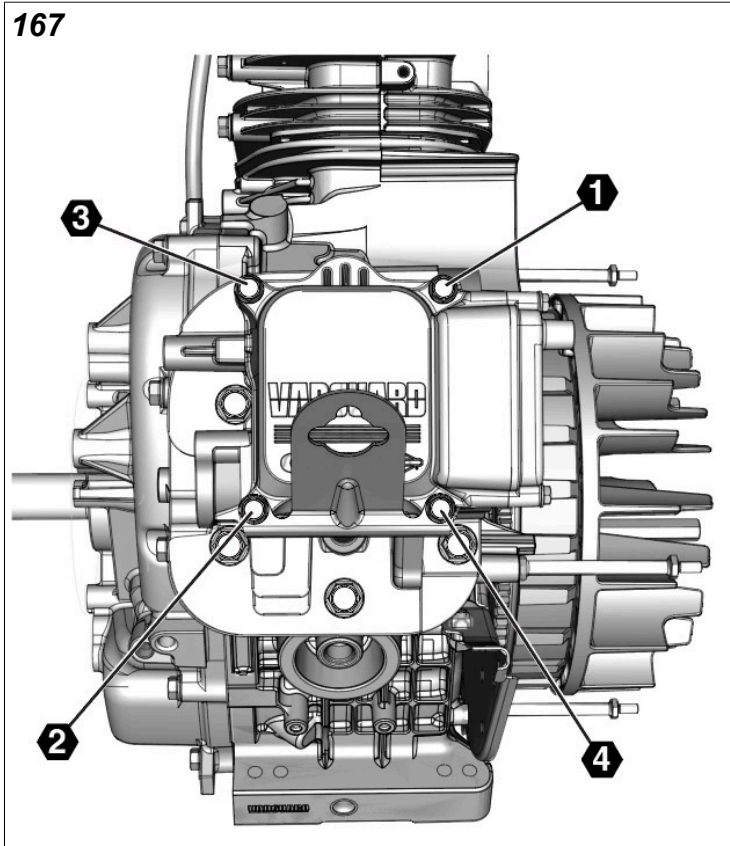
- Insert push rods into cylinder head bores to engage valve tappets. Rotate push rods to be sure that ball ends are seated in valve tappet sockets as shown in Figure 166.



- Install adjuster screws (**D**, Figure 165) and lock nuts (**E**) onto rocker arms.
- Tighten adjuster screws to obtain zero clearance between rocker arms and valve stem tips (**F**). Tighten lock nuts until snug.
- Repeat steps 7-10 on opposite cylinder.
- Slowly rotate crankshaft to verify proper movement of push rods and rocker arms.
- Adjust valve clearance. See *SECTION 2 - MAINTENANCE, CHECK/ADJUST VALVE CLEARANCE*.
- Slowly rotate crankshaft 3 full turns to seat valve train.
- Recheck valve clearance and adjust if necessary.
- Verify that mating surfaces of cylinder heads and valve covers are clean and dry. Any dust or dirt left on mating surfaces can cause leaks.
- Install **new** valve cover gaskets onto valve covers.

18. Start 4 fasteners to secure valve covers to cylinder heads. Alternately tighten fasteners to **70 lb-in (7.9 Nm)** using the sequence shown in Figure 167.

NOTE: The engine lifting brackets are secured by the valve cover bolts. Make sure that the lifting brackets and any auxiliary brackets, such as the electric fuel lift pump bracket or any other equipped component bracketry, are installed prior to torquing the valve cover fasteners.



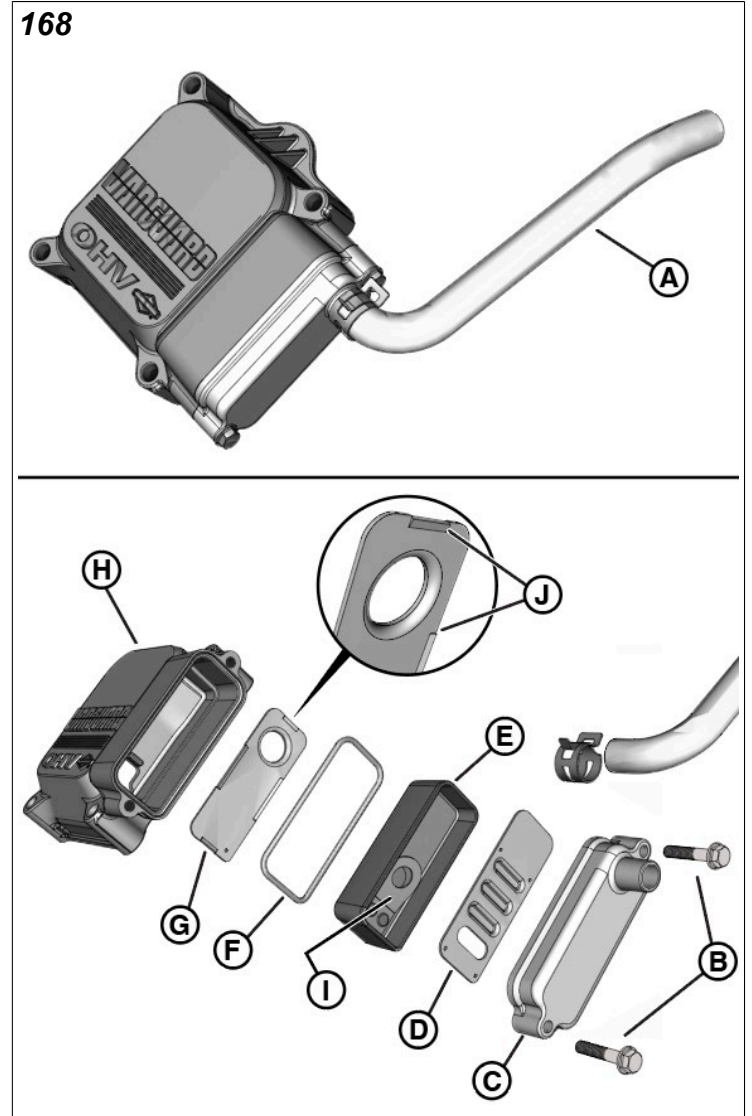
19. Install spark plugs into cylinder heads and finger tighten until snug. Tighten spark plugs to **170 lb-in (19.2 Nm)** using a 5/8 inch spark plug wrench.

NOTE: Do not install spark plug wires onto spark plug terminals at this time.

20. See SECTION 8 - INSTALL EXTERNAL ASSEMBLIES.

Crankcase Breather

1. Check crankcase breather as follows:
 - A. Gently blow air into breather hose (A, Figure 168) to verify that there is no air flow through valve.
 - B. Apply vacuum or draw air out through breather hose to verify that air flows freely through valve.
 - C. If air flow has no resistance when blowing or is restricted under vacuum, the breather is faulty.



2. Remove two hex flange screws (B) to release breather cover (C).
3. Remove outer baffle (D).
4. Remove the reed valve assembly (E) and O-ring (F).
5. Remove inner baffle (G) from the valve cover (H).
6. Check for loose rivets and for damage to the reed valve (I), reed stop and housing. Replace components if worn or damaged, or if the reed valve does not lay flat over the valve cover opening.

7. Install the inner baffle (**G**) with raised edges (**J**) facing OUT.

NOTE: DO NOT forcibly install components. One corner of the breather components have a sharper radius than the others to ensure correct alignment.

8. Install the reed valve assembly (**E**) into the valve cover (**H**) with the reed valve facing out.

9. Install O-ring (**F**) into valve cover groove. Inspect for dryness, cracking, or cuts.
10. Install the outer baffle (**D**) into the breather cover with the three bosses facing out.
11. Install the breather cover (**C**) and baffle onto the valve cover.
12. Start 2 fasteners (**B**) and alternately tighten to **43 lb-in** (4.9 Nm).

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INSTALL EXTERNAL ASSEMBLIES

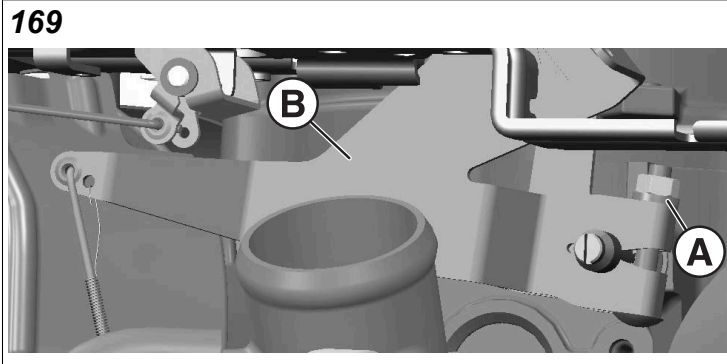
Preliminary Instructions

Prior to starting any repair or maintenance operation. Make sure you are familiar with ALL safety warnings and procedures as outlined in *SECTION 1 - SAFETY AND GENERAL INFORMATION - Safety Information*.

ALWAYS wear safety glasses and gloves while performing any maintenance and repair operation.

Governor Arm Bracket

1. Install the governor arm bracket onto the governor shaft (A, Figure 169).



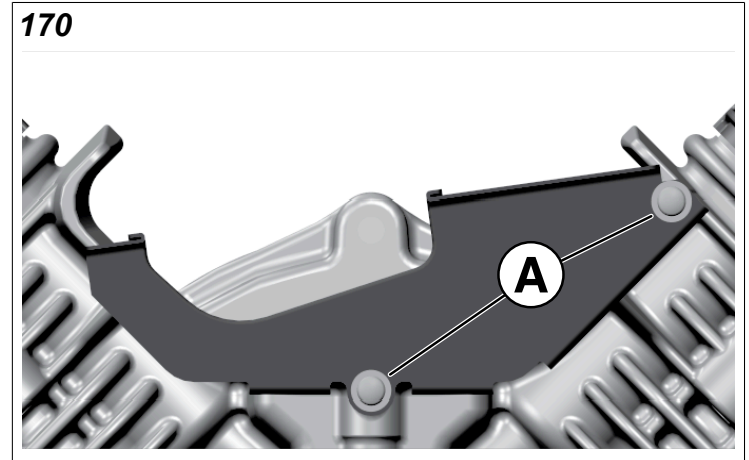
2. Perform static governor adjustment. See *SECTION 2 - MAINTENANCE - Static Governor Adjustment*.
3. Tighten the governor arm bracket pinch bolt (B) to **135 lb-in** (15.3 Nm).
4. Attach the 2 governor arm springs in the same position as noted when removed.

NOTE: The 2 governor arm springs attach to the speed control bracket. The configuration of the speed control bracket is dependent on the trim of the engine. Once installed, attach the 2 governor arm springs from the governor arm to the speed control bracket using the positions noted from disassembly.

Air Block Plate, Valley Air Guides, Speed Control Bracket

1. Install the air block plate on the engine block.

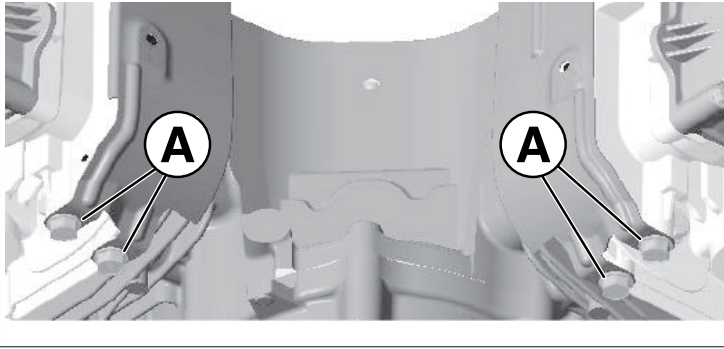
2. Start the 2 air block plate fasteners (A, Figure 170) by hand. Tighten to **18 lb-in** (2 Nm).



3. Install the left and right valley air guide onto the engine.

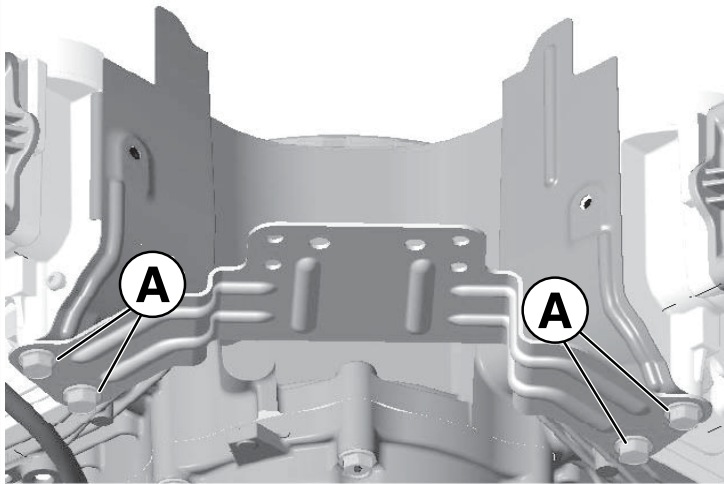
4. Start the 4 air guide fasteners by hand (A, Figure 171). Tighten to **195 lb-in** (22 Nm).

171

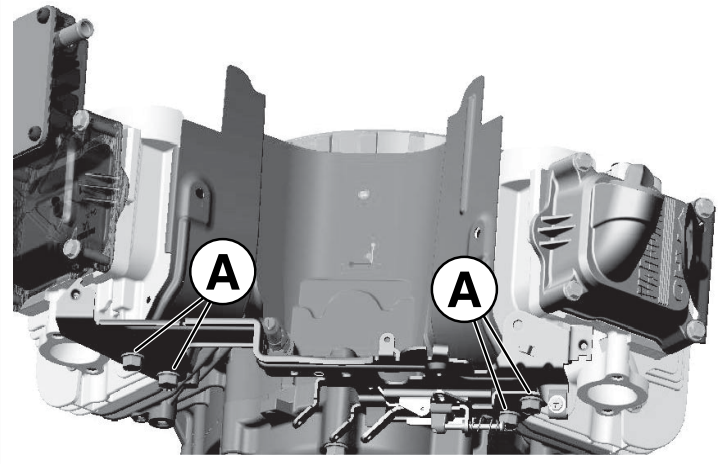


NOTE: Your engine may be equipped with an air filter support bracket or a speed control bracket. These brackets utilize the valley air guide fasteners to attach to the engine. See Figure 172 for engines equipped with the low-profile air cleaner support bracket, and see Figure 173 for engines equipped with the speed control bracket.

172

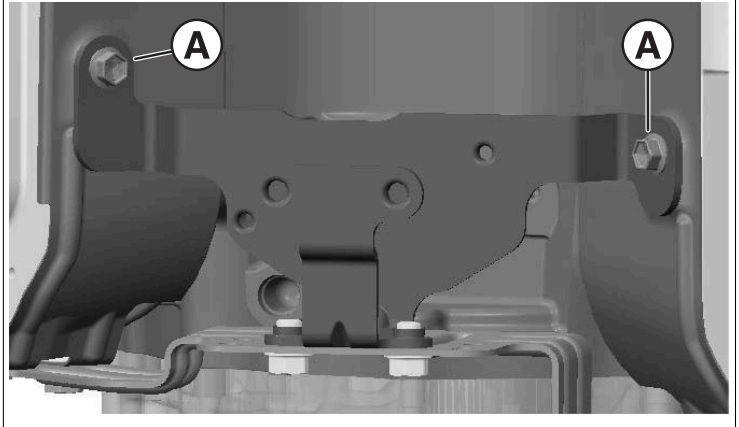


173



5. If equipped, install the valley component bracket (A, Figure 174) in the valley of the engine block.

174



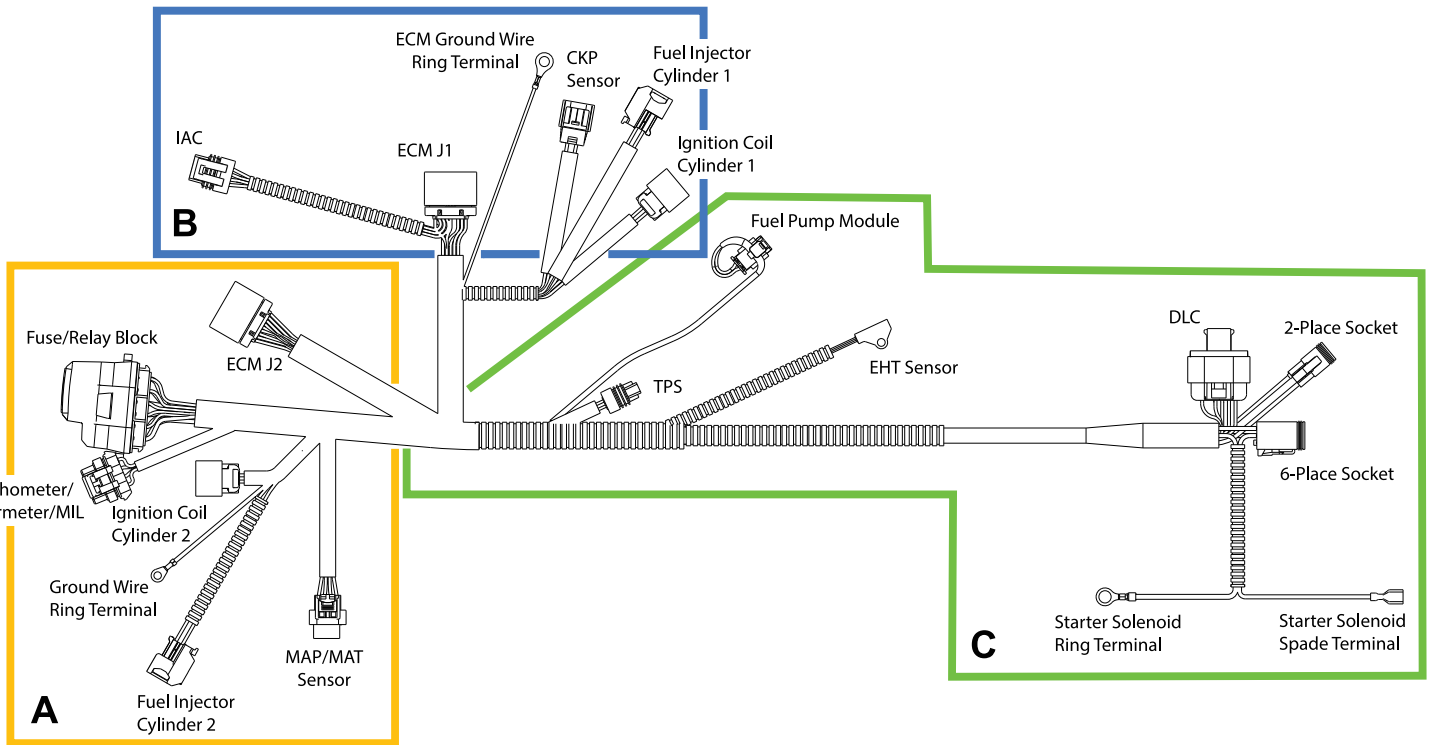
6. Start the 2 component bracket fasteners by hand. Tighten to **90 lb-in** (10.2 Nm).

Wire Harness - EFI

The instructions for the installation of the wiring harness for EFI engines can be used as a stand-alone instruction for the wiring harness on an assembled engine OR in conjunction with the assembly process of a disassembled engine.

If you are installing the engine wiring harness as a part of the assembly process of a disassembled engine, reserve the instructions to connect the harness to various components until those components have been assembled on the engine.

1. Position EFI wire harness at top of intake manifold separating conduit and connectors into three groups as shown in Figure 175.
2. See section C of Figure 175. Feed wire harness connectors and conduit down through air block mounting plate opening to area below intake manifold.
3. See section B of Figure 175. On cylinder 1 side of engine, proceed as follows:
 1. Connect ECM J1 connector.
 2. Slide fastener through ECM flange (Grey ECM J1 connector side) and ground wire ring terminal. Start fastener into ECM/fuse block bracket and tighten to **44 lb-in** (5 Nm).
 3. Connect fuel injector connector. Push in green secondary lock to secure.
 4. Install **new** cable strap through ignition coil wire harness socket connector, install over inside ignition coil mounting boss, and connect connector.
 5. Connect CKP sensor connector.
 6. Connect IAC connector.
4. See section A of Figure 175. On cylinder 2 side of engine, proceed as follows:
 1. Install fastener for fuse block cover to ECM/fuse block bracket. Tighten fastener to **87 lb-in** (9.8 Nm).
 2. Connect MAP/MAT sensor connector. Push in red secondary lock to secure.
 3. Connect fuel injector connector. Push in green secondary lock to secure.
 4. Install **new** cable strap through ignition coil wire harness socket connector, install over inside ignition coil mounting boss, and connect connector.
 5. Install ground wire ring terminal to cylinder boss and start fastener. Tighten fastener to **29 lb-in** (3.3 Nm).
 6. Connect ECM J2 connector.
5. See section C of Figure 175. Proceed as follows:
 1. Connect TPS connector.
 2. Connect fuel pump module connector. Push in grey secondary lock to secure.
 3. Orient EHT sensor with end rotated against tab on cylinder 1. Install fastener and tighten to **44 lb-in** (5 Nm).
 4. Connect starter solenoid ring and spade terminals.
 5. Connect 2- and 6-place (or single 8-place) engine to chassis connectors.
6. Install 2 fasteners (with captive washers) to fasten air block mounting plate to cylinder. Alternately tighten screws to **29 lb-in** (3.3 Nm).
7. Install **new** cable strap around intake manifold between air block mounting plate and inside cylinder 2 ignition coil mounting boss capturing convoluted tubing of ignition coil and fuel injector.
8. Install **new** cable strap around intake manifold between air block mounting plate and inside cylinder 1 ignition coil mounting boss capturing fuel injector, ignition coil and CKP sensor conduit.



Wire Harness - EFI-ETC

The instructions for the installation of the wiring harness for EFI and EFI-ETC engines can be used as a stand-alone instruction for the wiring harness on an assembled engine OR in conjunction with the assembly process of a disassembled engine.

If you are installing the engine wiring harness as a part of the assembly process of a disassembled engine, reserve the instructions to connect the harness to various components until those components have been assembled on the engine.

1. See inset of Figure 177. Starting with the main vehicle connector and ending with the fuse/relay block, feed branches of wire harness down through opening next to air block plate.
2. Rotate air block plate in a clockwise direction and install Phillips screw to fasten plate to crankcase. Tighten screw to **18 lb-in** (2 Nm).
3. Connect ECM connector (**R**, Figure 176).
4. Install Phillips screw to fasten ECM ground wire ring terminal (**S**) to throttle body. Tighten screw to **18 lb-in** (2 Nm). If loosened or removed, install hex nuts onto two studs to secure air intake elbow. Tighten nuts to **90 lb-in** (10.2 Nm).
5. Install Phillips screw to fasten engine ground wire ring terminal (**T**) to crankcase boss. Tighten screw to **45 lb-in** (5 Nm).
6. Install anchor of fir tree style clip (**Q**, Figure 177) capturing MIL, ECM, and ground wire ring terminal conduit into hole in intake manifold boss next to air cleaner bracket stud.

7. Running conduit between intake manifold and fuel rail, connect cylinder 2 fuel injector connector (**P**, Figure 176). Push in white secondary lock. If removed, install fuel injector cap screw and tighten to **110 lb-in** (12.4 N-m).
8. Running conduit between intake manifold and fuel rail, connect cylinder 1 fuel injector connector (**N**). Push in white secondary lock. Install anchor of fir tree style clip (**O**, Figure 177) into hole in boss at top of intake manifold. If removed, install fuel injector cap screw and tighten to **110 lb-in** (12.4 Nm).
9. Connect cylinder 2 ignition coil connector (**M**, Figure 176) at top of intake manifold. Push in red secondary lock.
10. Connect cylinder 1 ignition coil connector (**L**, Figure 177). Push in red secondary lock. Install anchor of rosebud style clip into hole in boss at bottom of intake manifold. Install two screws to fasten ignition coil to intake manifold bosses, if removed. Tighten screws to **30 lb-in** (3.4 Nm).
11. Connect CKP sensor connector (**K**, Figure 176).

12. Proceed as follows:

A. Cylinder 2 (Oil Filter) Side:

- Capture wire harness (ignition coil, fuel injector, and ground wire ring terminal conduit) in double-sided clamp (**W**). Opposite side of clamp captures fuel rail hose.
- Start short hex flange screw (**X**) to fasten clamp to intake manifold boss. Tighten screw to **90 lb-in** (10.2 Nm).
- Install long hex flange screw (**U**) to fasten fuse/relay block bracket (**V**) to clamp. Tighten screw to **90 lb-in** (10.2 N-m).

B. Cylinder 1 (Starter Motor) Side:

- Capture wire harness (CKP sensor, ignition coil, and fuel injector conduit) in single-sided clamp (**Z**).
- Start hex flange screw (**Y**) to fasten clamp to intake manifold boss. Tighten screw to **90 lb-in** (10.2 Nm).

13. Connect fuse/relay block to cover (**J**).

14. Connect fuel pump module connector (**F**). Push in grey secondary lock.

15. Start long hex flange screw to fasten fuel pump module bracket and fuse/relay block bracket to cylinder 2 head. On opposite side, start short hex flange screw to fasten fuel pump module bracket and EFI wire harness clip (capturing O₂ sensor and EHT sensor conduit) to cylinder head. Tighten both fasteners to **90 lb-in** (10.2 Nm).

16. Install fastener to secure EHT sensor (**I**) to cylinder 1 head and tighten to **45 lb-in** (5 Nm).

17. Connect O₂ sensor connector (**H**), and install gray secondary lock.

18. Capture O₂ sensor conduit in clip (**G**) attached to fuel pump module bracket, if present.

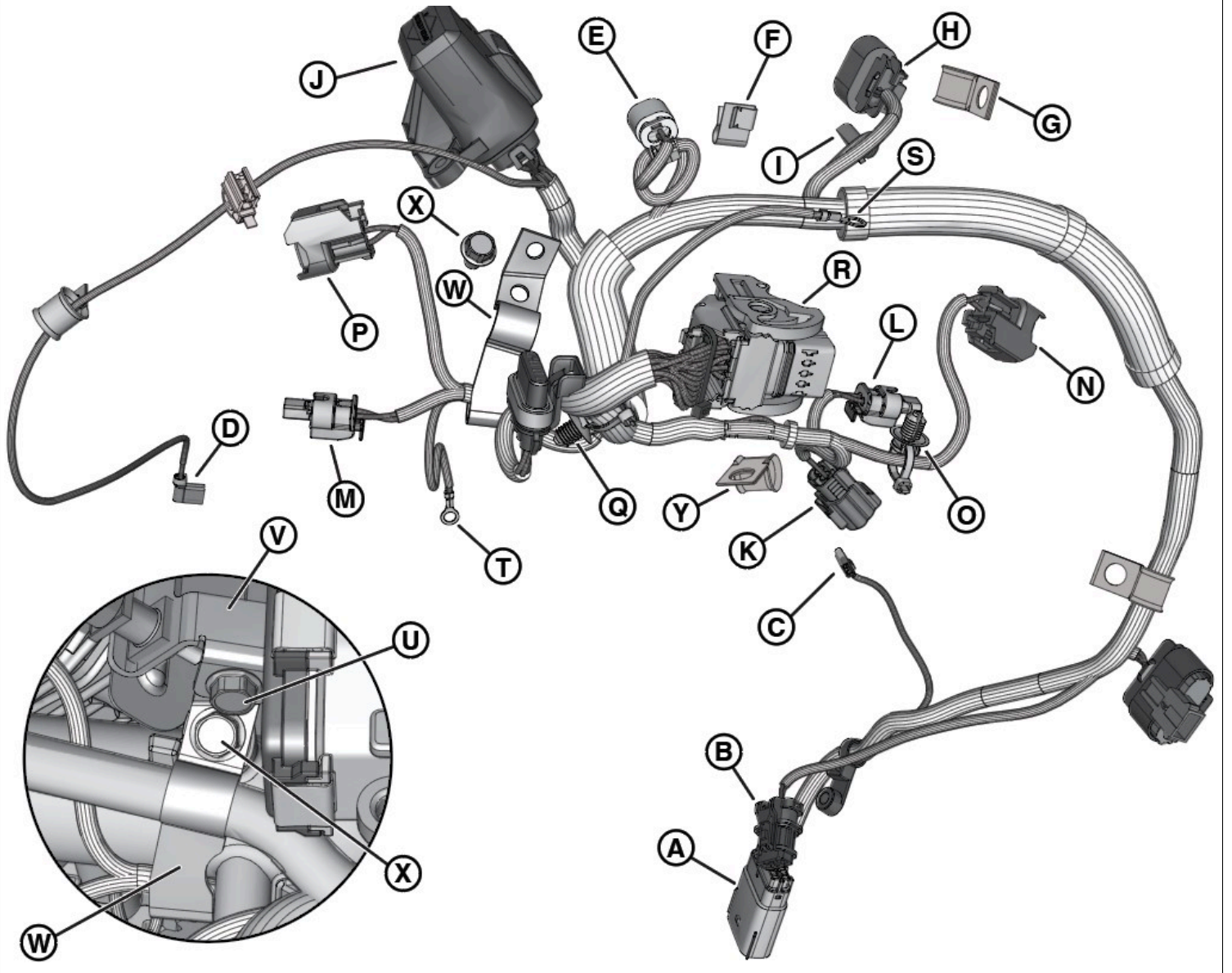
19. Connect elbow spade socket terminal (**E**) to oil pressure switch spade contact.

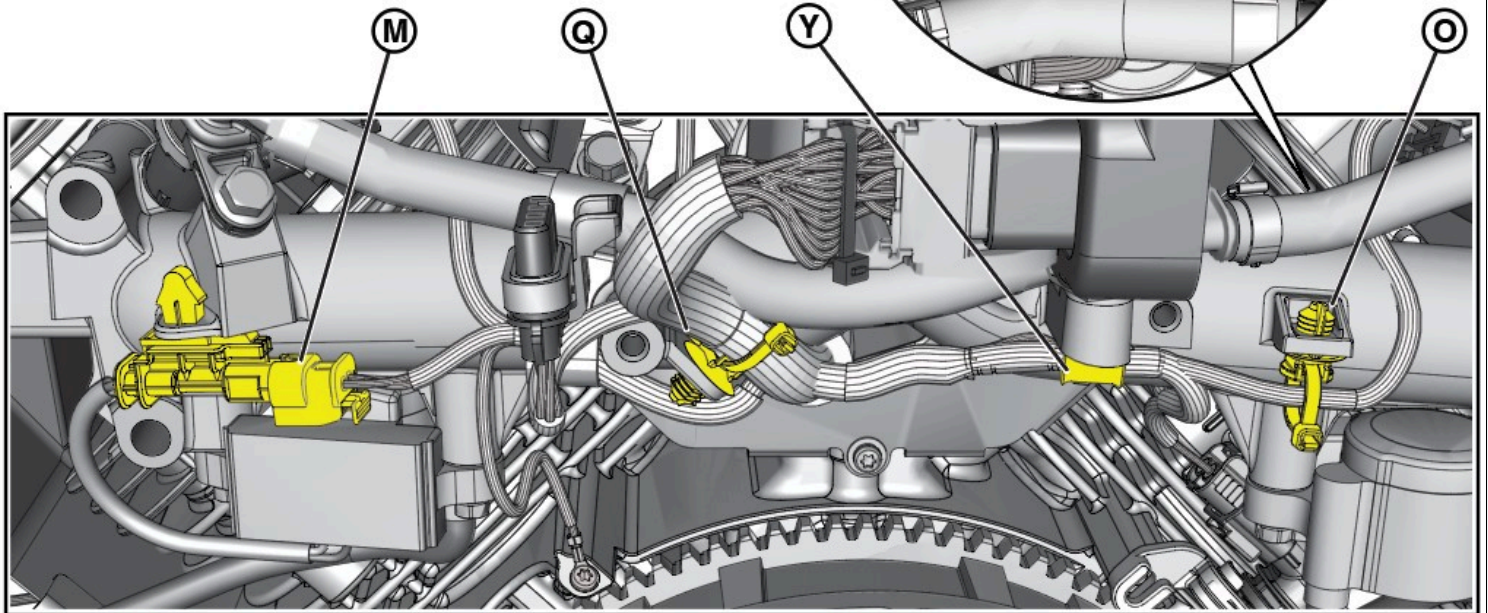
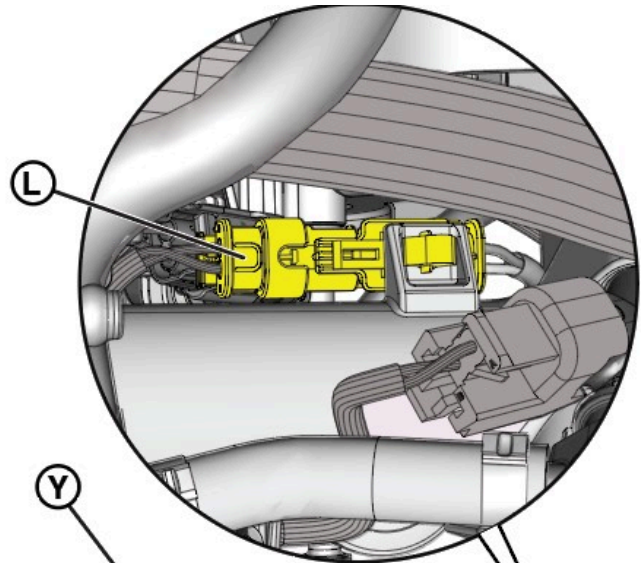
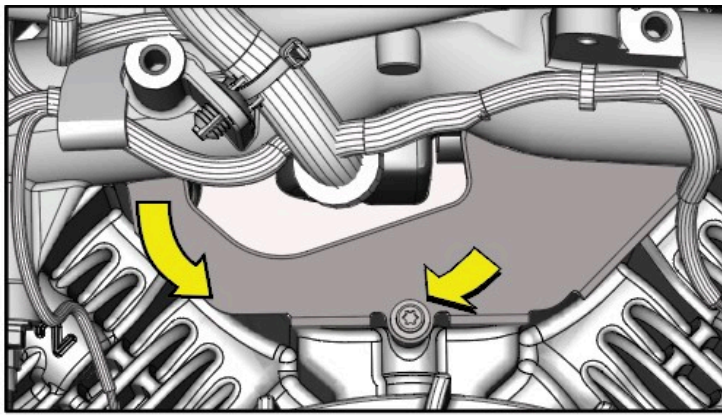
20. Install elbow spade socket terminal (**D**) onto starter solenoid spade contact.

21. Connect electric lift fuel pump connector (**C**).

22. Connect main vehicle connector (**B**).

23. Install fastener to secure wire harness clip (**A**) to lifting bracket. Tighten to **34 lb-in** (3.8 Nm).





Wire Harness - Carburetor and Gaseous

The instructions for the installation of the wiring harness for carbureted and gaseous engines can be used as a stand-alone instruction on an assembled engine OR in conjunction with the reassembly process of an engine.

If you are installing the engine wiring harness as a part of the reassembly process, reserve the instructions to connect the harness to various components until those components are installed on the engine.

1. Connect the starter solenoid spade connector (**B**, Figure 1) to the starter solenoid.
2. Connect the anti-afterfire solenoid connector, if equipped, (**D**) to the solenoid.

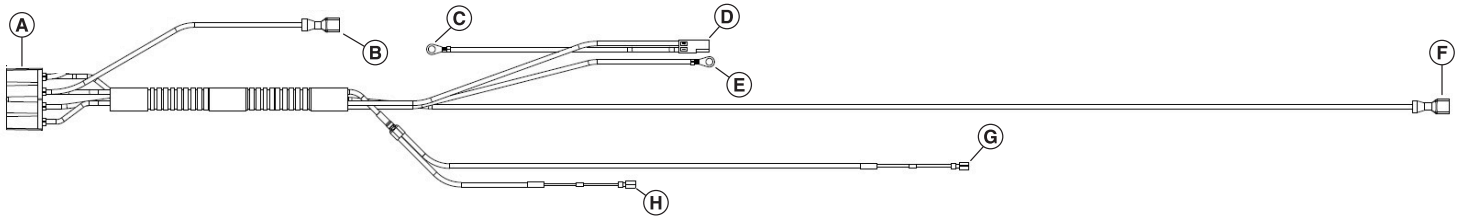
3. Secure the anti-afterfire ground ring terminal (**C**) and the harness ground ring terminal (**E**) to the engine with the fastener. Tighten fastener to **18 lb-in (2 Nm)**.

NOTE: The 2 ground wire ring terminals are secured to the engine by the lower air block plate fastener. If previously removed, install the air block plate at this time (see *Air Block Plate, Valley Air Guides, Speed Control Bracket* in this section).

4. Connect the ignition armature spade connectors (**G-H**) to the armatures.
5. Connect the oil pressure switch spade connector (**F**) to the switch.
6. Make sure that the oil pressure switch wire is routed through the opening between the air guide, back plate, and blower housing.
7. Secure the wire harness to the intake manifold with tie wraps in 2 locations. One in the middle of the #1 cylinder intake runner, and the other in the middle of the #2 cylinder intake runner.

- Reserve connecting the equipment harness connector (A) until all service and repairs are complete and the engine is safe to run.

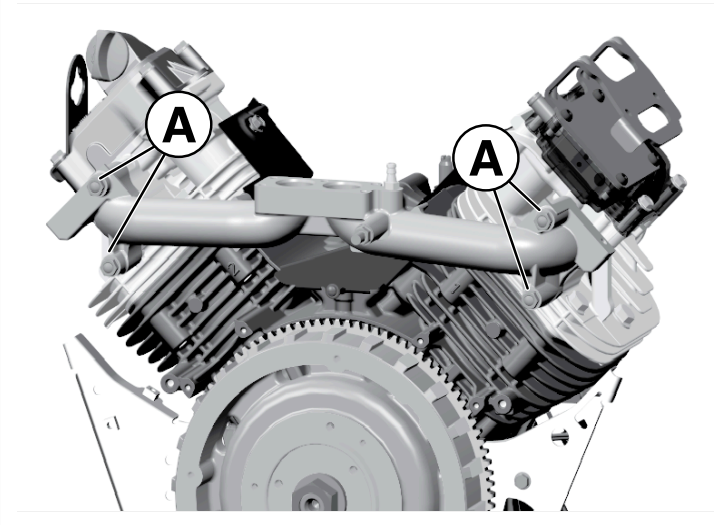
178



Intake Manifold

- Install the intake manifold (A, Figure 179) with **new** gaskets onto the manifold studs.

179



- Start the 4 intake manifold fasteners (B) by hand. Tighten to **135 lb-in** (15.3 Nm).

T-MAP Sensor - EFI

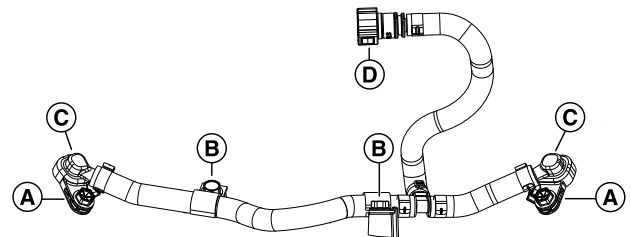
- Lightly lubricate the T-MAP sensor o-ring with clean engine oil.
- Install the sensor into the port on the intake manifold.
- Start the T-MAP sensor fastener by hand. Tighten to **90 lb-in** (10.2 Nm).
- Connect the wire harness connector to the T-MAP sensor connector.
- Press IN the red secondary connector lock to secure the connector to the sensor.

Fuel Rail and Fuel Injectors - EFI

- Lightly lubricate fuel injector O-rings with clean engine oil.

- Install fuel injectors into intake manifold.
- Install retaining clips to secure fuel injector caps to fuel injectors. Orient retaining clips as noted during removal. Be sure retaining clips are fully engaged.
- Install 2 fasteners to secure fuel injector cap flanges to intake manifold (A, Figure 180). Tighten to **113 lb-in** (12.8 Nm).

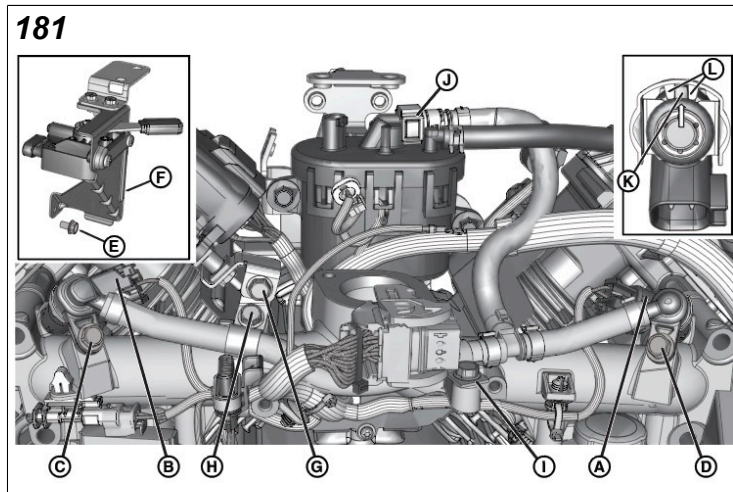
180



- Install fasteners to secure fuel rail clamps to intake manifold (B). Tighten to **87 lb-in** (9.8 Nm).
- Connect fuel injector connectors (C). Push in green secondary locks to secure.
- Firmly push quick disconnect fitting onto fuel pump module (D). Gently tug on fitting to verify that it is properly seated and secure.

Fuel Rail and Fuel Injectors - EFI-ETC

1. To install fuel rail, proceed as follows:



- A. Cylinder 1 (Oil Filter) Side:
- Place fuel rail into position, so that protective sleeve is positioned between two hose clamp bosses on the intake manifold
 - Install clamp on fuel rail hose.
 - Start fastener (I, Figure 181) to secure clamp to intake manifold boss. Tighten screw to **90 lb-in** (10.2 Nm).
 - Firmly push quick disconnect fitting (J) onto fuel outlet fitting. Gently tug on fitting to verify that it is properly seated and secured.
- B. Cylinder 2 (Starter Motor) Side:
- Install clamp on fuel rail hose. Verify that EFI wire harness is captured in opposite side of clamp (ignition coil, fuel injector, and ground wire ring terminal conduit).
 - Start short hex flange screw (H) to fasten clamp to intake manifold boss. Tighten screw to **90 lb-in** (10.2 Nm).
 - Rotate fuse/relay block bracket inward to align clamp and bracket holes (clamp positioned below bracket).
 - Install long hex flange screw (G) to fasten bracket to clamp. Tighten screw to **90 lb-in** (10.2 Nm).
 - If equipped, connect throttle lever module connector, and then install hex flange screw (E) to fasten throttle lever bracket (F) to intake manifold boss. Tighten screw to **90 lb-in** (10.2 Nm).
2. Lightly lubricate fuel injector o-rings with clean engine oil.
3. Install fuel injector caps onto fuel injectors.

4. Install retaining clips to secure fuel injector caps to fuel injectors.

NOTE: Be sure retaining clips are properly installed. Side slots on clip engage lip on cap, while tab (K) on fuel injector body is captured between prongs (L) on clip.**NOTE:**

5. Install fuel injectors into intake manifold bores.
6. Install 2 fasteners (D and C) to secure fuel injector cap flanges to intake manifold. Tighten fasteners to **110 lb-in** (12.4 Nm).
7. Connect fuel injector connectors (B and A). Push in white secondary locks to secure.
8. Rotate each fuel injector until connector makes light contact with the intake manifold.

Carburetor and Spacers

Your engine may be equipped with either a cyclonic air cleaner assembly or a low-profile air cleaner assembly. On engines equipped with a low-profile air cleaner, the air cleaner base makes use of 4 studs that secure the intake adaptor, carburetor, spacers and gaskets to the intake manifold. For this style of air cleaner, proceed to *Low Profile Air Cleaner Equipped Engines*, see Figure .

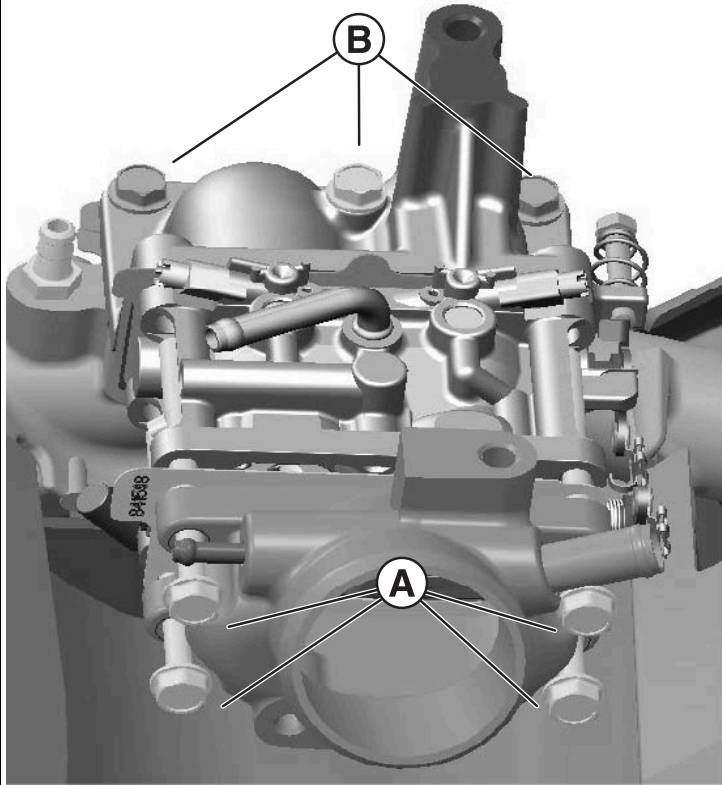
Engines equipped with a cyclonic air cleaner assembly will have an intake elbow that makes use of 4 studs to secure the carburetor, spacers and gaskets to the intake manifold. For this style of air cleaner, proceed to *Cyclonic Air Cleaner Equipped Engines*, see Figure .

Cyclonic Air Cleaner Equipped Engines

1. Install the **new** gaskets and spacers between the carburetor and intake manifold (**Vertical Shaft** engines) or intake elbow (**Horizontal Shaft** engines).

2. On **Horizontal Shaft** engines, install the 3 fasteners that secure the intake elbow to the intake manifold (**B**, Figure 182). Tighten to **90 lb-in** (10.2 Nm).

182

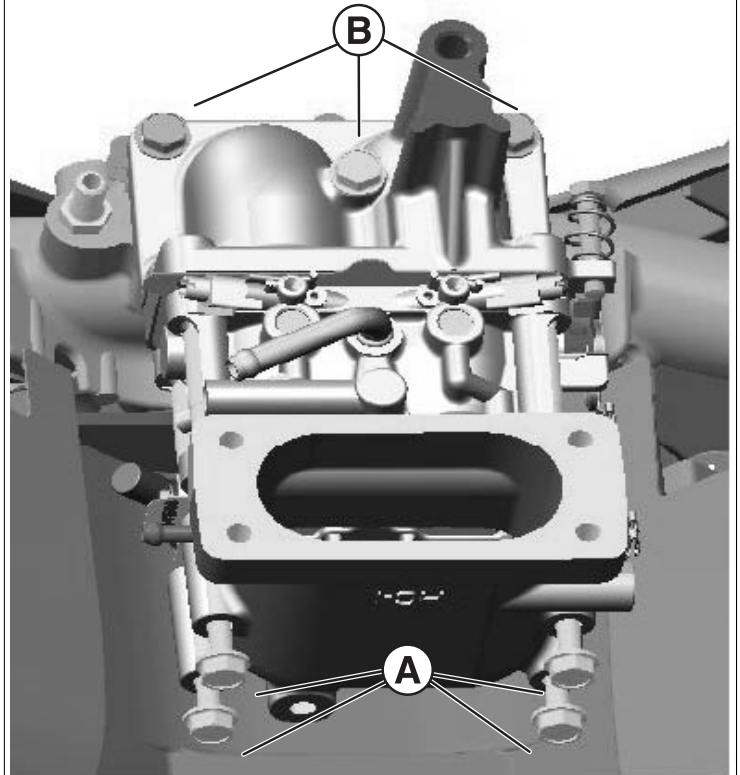


3. Install the carburetor, with **new** gaskets and spacer onto the intake elbow.
4. Lift the carburetor **SLIGHTLY** to allow for the connection of the throttle rod and spring. Connect the throttle rod clip and install the spring. Install the throttle rod onto the throttle lever at the carburetor.
5. Start by hand the 4 fasteners (**A**) that secure the carburetor to the intake elbow (**Horizontal Shaft** engine) or intake manifold (**Vertical Shaft** engine). Tighten to **90 lb-in** (10.2 Nm).
6. Connect the anti-afterfire solenoid wire harness connector to the solenoid.
7. Connect the carburetor choke rod at the carburetor.
8. Connect the fuel pump vent line at the intake manifold port. Squeeze the tangs of the clamp and slide the clamp toward the intake manifold until directly over the port.
9. Connect the fuel feed line from the fuel pump to the carburetor inlet port. Squeeze the tangs of the clamp and slide the clamp toward the carburetor until directly over the port.
10. Connect the fuel vent line to the intake elbow port.
11. Connect the valve cover breather hose to the carburetor port.

Low-Profile Air Cleaner Equipped Engines

1. Install the **new** gaskets and spacers between the carburetor and intake manifold (**Vertical Shaft** engines) or intake elbow (**Horizontal Shaft** engines).
2. On **Horizontal Shaft** engines, install the 3 fasteners that secure the intake elbow to the intake manifold (**B**, Figure 183). Tighten to **90 lb-in** (10.2 Nm).

183



3. Install the carburetor, with **new** gaskets and spacer onto the intake elbow.
4. Lift the carburetor **SLIGHTLY** to allow for the connection of the throttle rod and spring. Connect the throttle rod clip and install the spring. Install the throttle rod onto the throttle lever at the carburetor.
5. Start by hand the 4 fasteners (**A**) that secure the air cleaner base to the carburetor and intake adaptor (**Horizontal Shaft** engine) or intake manifold (**Vertical Shaft** engine). Tighten to **90 lb-in** (10.2 Nm).
6. Connect the anti-afterfire solenoid wire harness connector to the solenoid.
7. Connect the carburetor choke rod at the carburetor.
8. Connect the fuel pump vent line at the intake manifold port. Squeeze the tangs of the clamp and slide the clamp toward the intake manifold until directly over the port.
9. Connect the fuel feed line from the fuel pump to the carburetor inlet port. Squeeze the tangs of the clamp and slide the clamp toward the carburetor until directly over the port.

10. Connect the fuel vent line to the intake elbow port.
11. Connect the valve cover breather hose to the carburetor port.

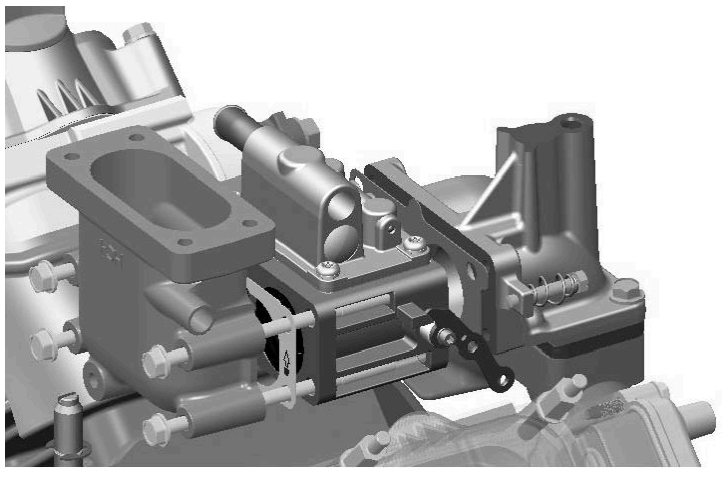
Anti-Afterfire Solenoid

1. Install the anti-afterfire solenoid and **new** washer into the carburetor bowl by turning the solenoid **CLOCKWISE**.
2. Tighten until snug. **DO NOT** overtighten, damage to the float bowl may occur.
3. Connect the wire harness connector to the solenoid connector.

Mixer and Spacers - Gaseous

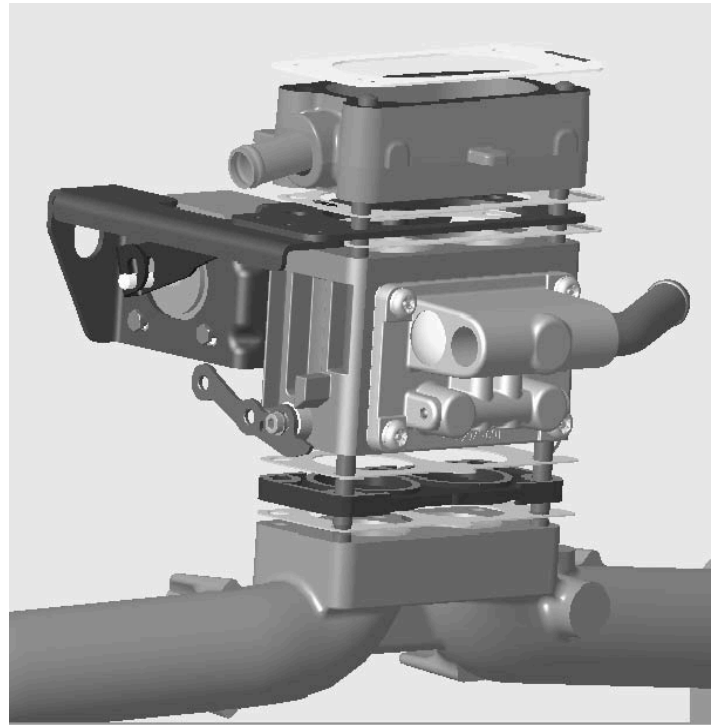
1. On **horizontally-mounted** mixers, install **new** gaskets and spacers between the intake manifold and lower intake manifold elbow. Start by hand the 3 fasteners that secure the intake manifold elbow to the intake manifold. Remove the elbow and insulator spacer from the manifold. Tighten to **90 lb-in** (10.2 Nm).
2. On **vertically-mounted** mixers, install **new** gaskets and insulator spacer to the intake manifold.
3. Install the mixer assembly to intake manifold or intake elbow with **new** gaskets.
4. Install the stepper motor and bracket (if equipped) with **new** gasket.
5. On **horizontally-mounted** mixers, install the upper intake manifold elbow with **new** gaskets, using Figure 184 as a reference. Install the 4 upper intake elbow fasteners. Tighten to **90 lb-in** (10.2 Nm).

184



6. On **vertically-mounted** mixers, install **new** gaskets and spacer between the mixer or stepper motor bracket (if equipped), using Figure 185 as a reference.

185



7. On engines equipped with the optional **Actuator**, connect the actuator link and spring to the throttle lever. Install the clevis, clip, spring, and attach the end of the actuator link to the bushing hole of the throttle lever.

NOTE: The actuator assembly is attached to the support bracket. To install the actuator to the engine, install the fasteners between the actuator and the support bracket. Tighten to **90 lb-in** (10.2 Nm).

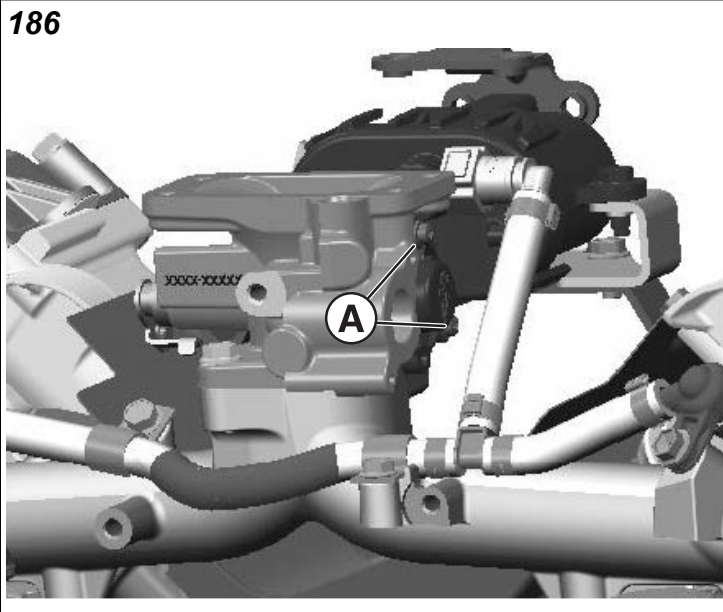
8. On engines equipped with a **Stepper Motor**, connect the governor link to the stepper motor by attaching the clip to the clevis.
9. Connect the governor link rod and spring to the throttle lever. Attach the link rod clip and spring, and connect the link rod to the throttle lever bushing hole.
10. Install the air cleaner base with **new** gasket.
11. Start by hand the 4 air cleaner base plate and mixer shield fasteners. Tighten to **90 lb-in** (10.2 Nm).

NOTE: Depending on the configuration of your engine, the air cleaner base may be attached with 4 bolts or 2 bolts and 2 studs with nuts.

12. Install the air cleaner base to support bracket fasteners. Tighten to **115 lb-in** (13 Nm).
13. Connect the fuel feed line to the mixer inlet port. Squeeze the tangs of the clamp and slide the clamp toward the mixer until directly over the port.
14. Connect the valve cover breather to the port on the spacer.

Throttle Position Sensor (TPS) - Late Style

1. Install the TPS into the throttle body.
2. Start the 2 fasteners (A, Figure 186) by hand. Tighten to **13 lb-in** (1.5 Nm).



3. Connect the wire harness connector to the TPS connector.

Throttle Position Sensor (TPS) - Early Style

1. Install the dead idle screw with spring on to TPS. Leave loose for later adjustment.
2. Install the TPS onto the throttle body. Start the 2 fasteners by hand. Leave loose for later adjustment.
3. See *Throttle Position Sensor (TPS) - Adjustment* for proper adjustment and torque specification for the TPS.

Throttle Position Sensor (TPS) - Adjustment

This adjustment procedure only applies to early style adjustable TPS. Late style TPS are non-adjustable. For TPS identification, refer to *SECTION 4 - REMOVE EXTERNAL ASSEMBLIES - Throttle Position Sensor (TPS)*.

NOTE: Adjustment of the TPS requires the engine to be running. Finish all service and repair procedures and obey all safety messages contained in *SECTION 1 - SAFETY AND GENERAL INFORMATION* before running the engine.

There are 2 methods for adjusting the TPS, with the Diagnostic Tool and Software, and with a digital volt and ohm meter (DVOM). If using the Diagnostic Tool, proceed as follows, for DVOM adjustment skip to step 10.

1. Connect the Diagnostic Tool to the engine and open the Diagnostic Tool Software. See the Diagnostic Tool manual for instructions.
2. Start and run the engine at no-load idle, throttle in the idle position.

3. Using the Diagnostic Tool, select the **Dashboard** icon in the left sidebar to view the **Dealer** tab. Select the **Test Procedures** tab in the lower left corner.
4. Slew the **Idle Air Control Position (Steps)** to 0 steps.
5. Adjust the dead idle screw until the engine runs at 600 +/- 50 RPM.
6. Turn the engine off.
7. Close the **Test Procedures** tab, and with the throttle resting against the dead idle screw, use the software to adjust the **TPS Voltage** to 0.73 +/- .02 volts.
8. Alternately tighten two TPS screws to **13 lb-in** (1.5 Nm).
9. Proceed to step 14 to reset ECM memory.

Using DVOM

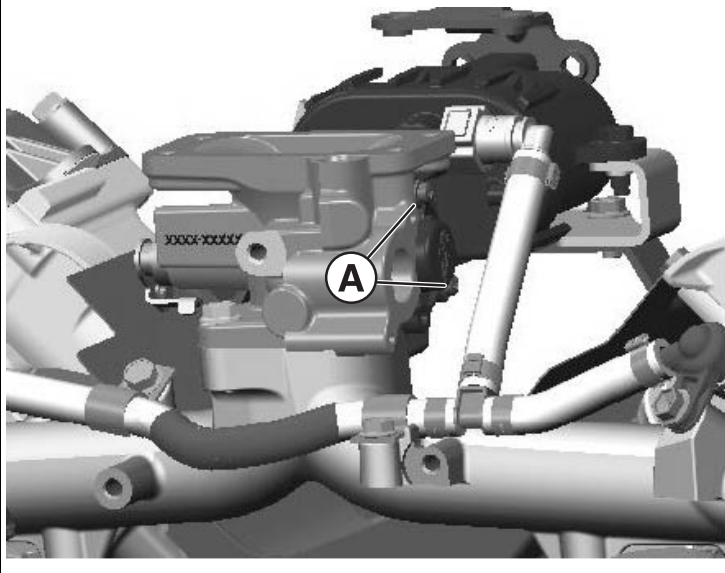
10. Start and run the engine at no-load idle, throttle in the idle position.
11. Use index finger or plug to block IAC air passage.
12. While IAC air passage is blocked, adjust dead idle screw until engine runs at 600 +/-50 RPM.
13. Turn engine OFF and proceed as follows:
 - A. Back probe terminal 3 (Pink/Black wire) of TPS connector.
 - B. Connect terminal 3 back probe to red meter test lead on DVOM.
 - C. Back probe terminal 2 (Brown wire) of TPS connector.
 - D. Connect terminal 2 back probe to black meter test lead on DVOM.
 - E. Set DVOM to read volts DC.
 - F. Turn Ignition ON, Engine OFF.
 - G. Observe voltage on DVOM.
 - H. With throttle resting against the dead idle screw, rotate the TPS until the output voltage is 0.73 +/- 0.02 volts.
 - I. Alternately tighten two TPS screws to **13 lb-in** (1.5 Nm).
14. Reset ECM memory as follows:
 - A. Turn Ignition OFF for at least 10 seconds.
 - B. Cycle Ignition ON and OFF five times in five seconds.
 - C. End cycle in the OFF position and wait at least 10 seconds.
 - D. Turn Ignition ON to reset ECM memory to the default values.

Idle Air Control Valve (IAC) - EFI

1. Install the IAC valve onto the throttle body.

2. Start the 2 fasteners (**B**, Figure 187) by hand. Tighten to **13 lb-in** (1.5 Nm).

187



3. Connect the wire harness electrical connector to the IAC valve connector.

Intake Elbow/Throttle Body Adaptor

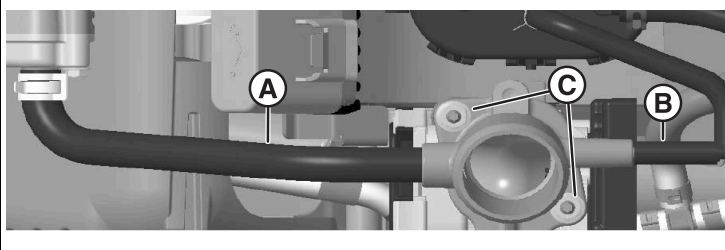
On engines equipped with a cyclonic air cleaner, an intake elbow is fitted. Follow the installation steps for the intake elbow.

On engines equipped with a low-profile air cleaner, a throttle body adaptor is fitted. Follow the installation steps for the throttle body adaptor.

Intake Elbow Installation

1. Install the intake elbow to the throttle body.
2. Start the 2 intake elbow fasteners (**C**, Figure 188) by hand. Tighten to **90 lb-in** (10.2 Nm).

188



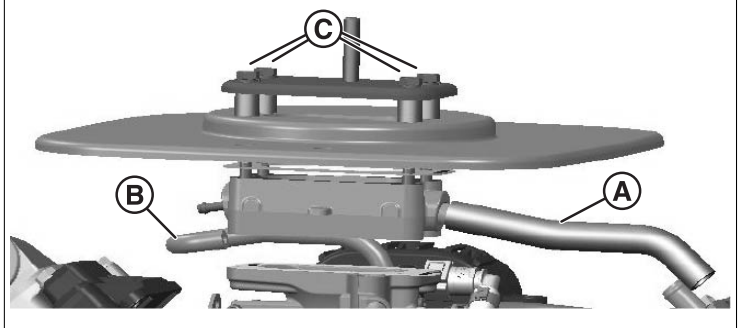
NOTE: Depending on your engine's trim, the intake elbow may be secured to the throttle body by either 2 or 4 fasteners. The installation procedure and torque specifications are the same regardless of the number of intake elbow fasteners.

3. Connect the crankcase breather hose to the large intake elbow port (**A**).
4. Connect the fuel vent line to the small intake elbow port (**B**). See *Fuel Pump Module - Install*.

Throttle Body Adaptor Installation

1. Install the throttle body adaptor with **new** gasket onto the throttle body.
2. If equipped, install the ECM/Fuse Block mounting bracket to the throttle body adaptor.
3. The throttle body adaptor is secured to the throttle body with 4 fasteners that also secure the low-profile air cleaner base.
4. Install the air cleaner base plate with **new** gasket onto the throttle body adaptor.
5. Start the 4 air cleaner base plate fasteners (**C**, Figure 189) by hand. Tighten to **90 lb-in** (10.2 Nm).

189

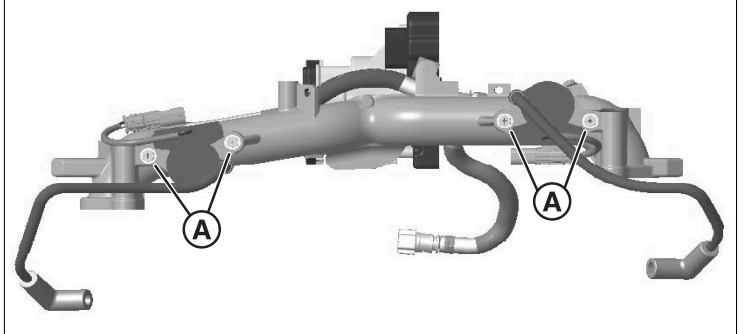


6. Start the air cleaner base plate to support bracket fasteners by hand. Tighten to **115 lb-in** (13 Nm).
NOTE: Depending on your engine's trim, the air cleaner base plate may be secured to a support bracket with either 2 or 4 fasteners. Regardless of the number of fasteners, the torque specification remains the same.
7. Connect the crankcase breather hose (**A**) to the large intake adaptor port.
8. Connect the fuel vent line (**B**) to the small intake adaptor port. See *Fuel Pump Module - Install*.

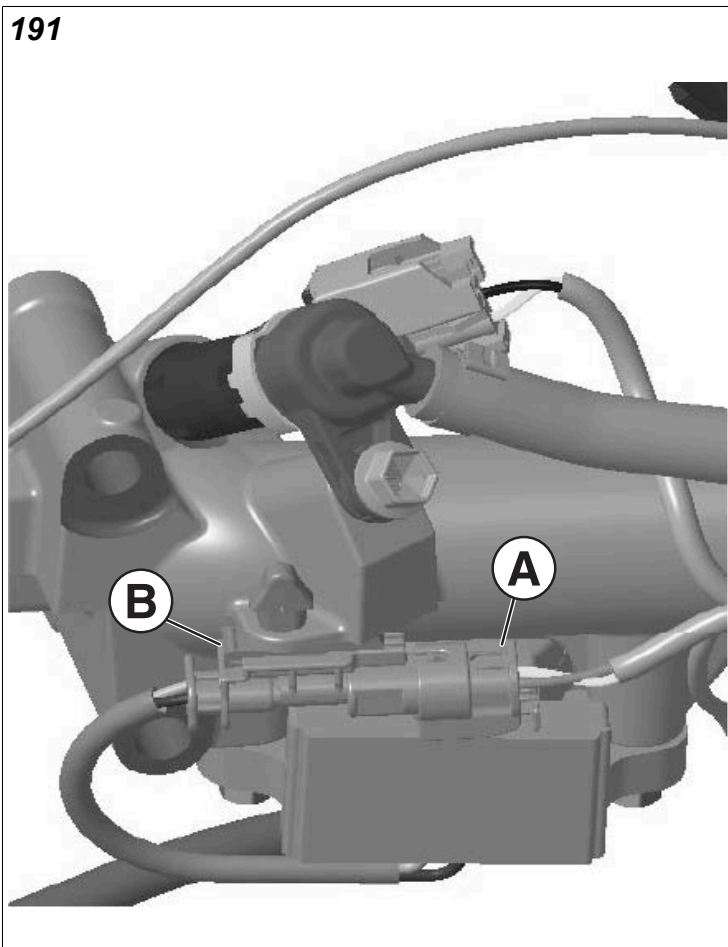
Ignition Coil - EFI and EFI-ETC

1. Install the ignition coil on to the intake manifold boss, aligning the mounting holes of the ignition coil with the threaded boss holes of the intake manifold.
2. Start the 2 ignition coil fasteners (**A**, Figure 190) by hand. Tighten to **30 lb-in** (3.4 Nm).

190



3. Install the wire harness connector for the ignition coil on to the intake manifold by sliding the attachment tab onto the intake manifold (**B**, Figure 191).



4. Connect the wire harness connector to the ignition coil connector (**A**).
5. Repeat steps for other ignition coil.

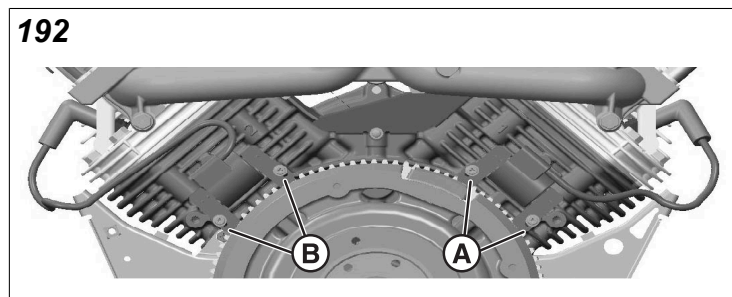
NOTE: DO NOT connect the ignition coil wires to the spark plugs until engine is completely assembled and ready to be started. See *Final Instructions*.

Ignition Coil/Armature - Carbureted and Gaseous

1. Starting with the armature for cylinder 1, install the armature on the crankcase bosses above the flywheel.

NOTE: The ignition coil/armature is labeled on one side with the phrase "This Side Out." You must install the armature in the correct orientation with the label facing the flywheel.

2. Apply a small amount of threadlocker (see *SPECIFICATIONS - Engine Fluids and Sealant Specifications*) to the armature fastener threads. Start the 2 armature fasteners by hand (**A-B**, Figure 192). Tighten until the fastener head makes contact with the armature. DO NOT overtighten as the armature air gap needs to be adjusted prior to final torqueing.



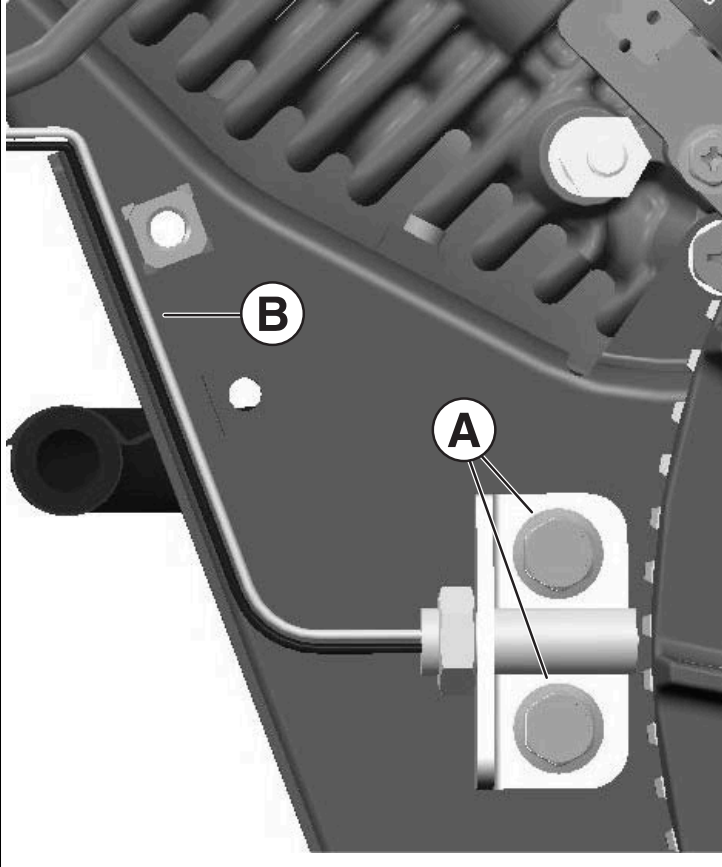
3. Using a feeler gauge, adjust the air gap between the armature arms and the flywheel to **0.008 in** (0.02 mm).
4. While maintaining the specified air gap, tighten the 2 armature fasteners to **30 lb-in** (3.4 Nm).
5. Repeat steps for cylinder 2 armature.

NOTE: DO NOT connect the ignition coil wires to the spark plugs until engine is completely assembled and ready to be started. See *Final Instructions*.

Optional Speed Sensor

1. Install the speed sensor onto the engine back plate. Align the 2 mounting holes with the threaded back plate holes.
2. Start by hand the 2 sensor fasteners (**A**, Figure 193). Tighten until fastener head makes light contact with the sensor mounting.

193



3. Using a feeler gauge, adjust the air gap between the sensor head and the flywheel teeth to **0.015 in** (0.38 mm).
4. While maintaining the specified sensor air gap, tighten the sensor fasteners to **60 lb-in** (6.8 Nm).

NOTE: DO NOT overtighten the sensor fasteners. Damage to the sensor casing may occur.

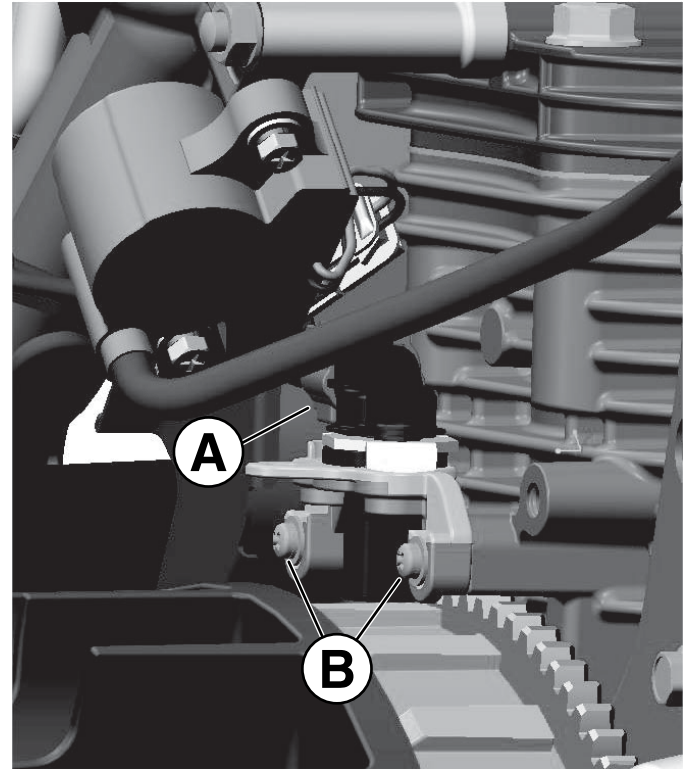
5. Route the sensor wiring along the engine back plate (**B**). The wiring will be **OUTSIDE** of the blower housing.
6. Connect the wire harness connector to the sensor wire connector.

Crankshaft Position Sensor (CKP)

1. Install the crankshaft position sensor onto the crankcase bosses above the flywheel on the cylinder 1 side of the engine.

2. Apply a small amount of threadlocker (see *SPECIFICATIONS - Engine Fluids and Sealant Specifications*) CKP fastener threads. Start the 2 sensor fasteners (**B**, Figure 194) by hand. Tighten until the fastener head makes contact with the sensor. **DO NOT** overtighten as the sensor air gap needs to be adjusted prior to final torquing.

194



3. Using a feeler gauge, adjust the sensor air gap to **0.010 in** (0.25 mm).
4. While maintaining the specified sensor air gap, tighten the 2 sensor fasteners to **23 lb-in** (2.6 Nm).
5. Connect the wire harness connector to the crankshaft position sensor electrical connector (**A**).

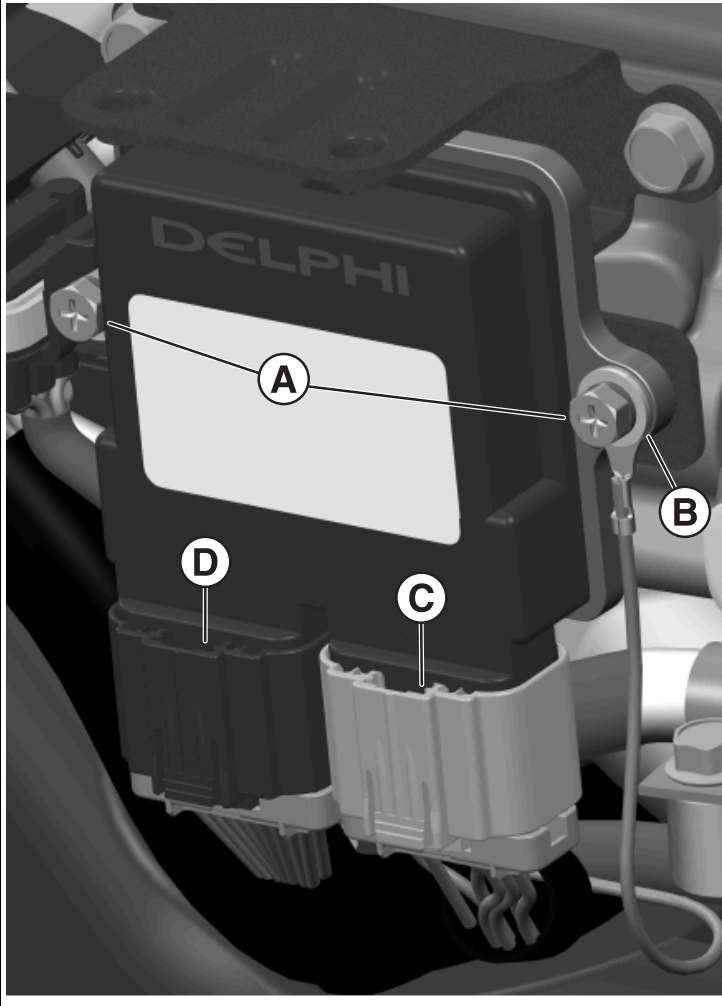
Engine Control Module (ECM) - EFI

Depending on the engine trim, an externally mounted ECM may be equipped. For installation instructions, proceed as follows:

1. Install the ECM onto the mounting bracket.

2. Start by hand the 2 fasteners that secure the ECM to the mounting bracket (A, Figure 195).

195



NOTE: A ground wire with a ring terminal from the engine wire harness is secured to the ECM with the mounting fastener. The ground wire should be located on the RIGHT side of the ECM and is secured between the fastener head and ECM mounting tab (B).

3. Tighten the 2 mounting fasteners to **35 lb-in** (4 Nm).
4. Connect the J1 (GRAY) (C) and J2 (BLACK) (D) wire harness connectors to the ECM in the orientation noted during disassembly. Press the harness connector onto the ECM connector until it "clicks."

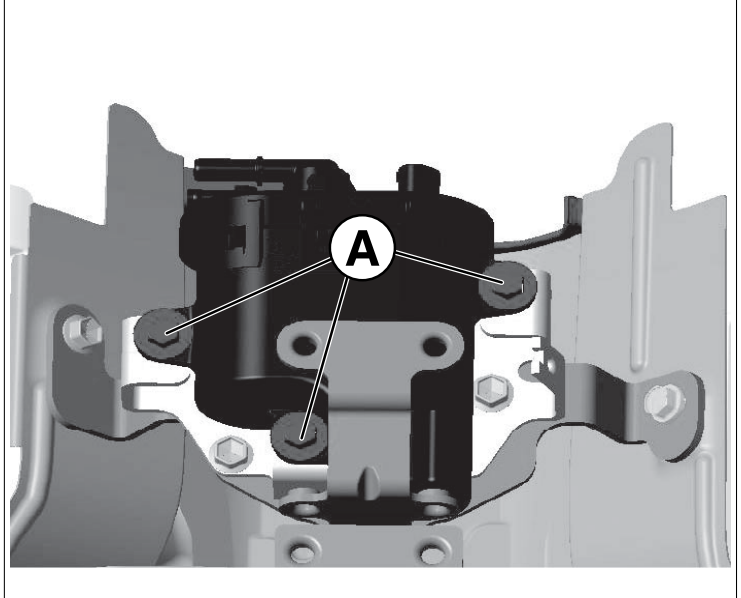
Fuel Pump Module

The fuel pump module is mounted to the engine in a number of ways based on the trim and engine orientation. If your engine is a vertical-shaft, proceed as follows. If your engine is a horizontal-shaft engine, skip to step 3.

1. On a vertical-shaft engine, install the fuel pump module onto the mounting bracket.

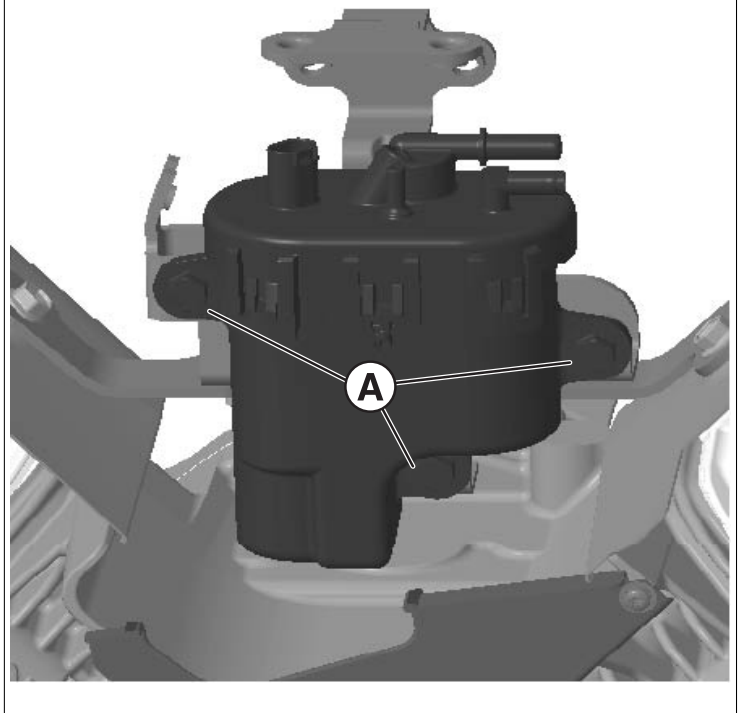
2. Start the 3 module fasteners by hand (A, Figure 196). Tighten to **90 lb-in** (10.2 Nm).

196



3. On a horizontal-shaft engine, it may be necessary to secure the fuel pump module to the mounting bracket prior to installation on the engine. If this configuration matches your engine, proceed as follows.
4. Install the fuel pump module onto the mounting bracket.
5. Start the 3 module fasteners by hand (A, Figure 197). Tighten to **90 lb-in** (10.2 Nm).

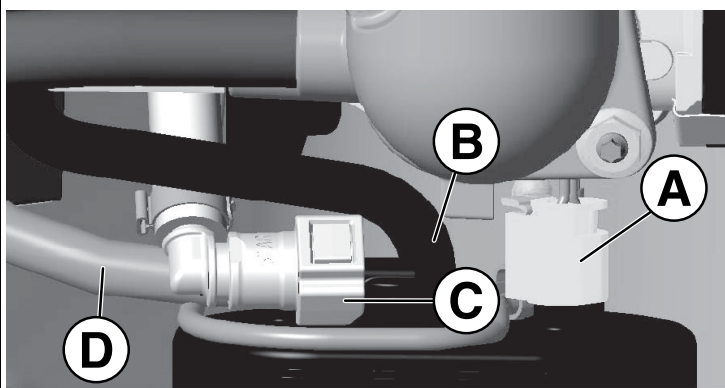
197



6. Install the fuel pump module and bracket assembly onto the engine support bracket.

7. Start the 3 fasteners by hand. Tighten to **115 lb-in** (13 Nm).
8. Install the fuel feed line (**C**, Figure 198), from fuel pump module to fuel injectors, by pressing the connector onto the port until it "clicks."

198



9. Install the fuel vent line (**B**), from the fuel pump module to the small port on the intake elbow or adaptor. Press the line onto the port, then squeeze the tangs of the clamp and slide along the vent line until positioned over the module port.
10. Connect the fuel supply line (**D**), then see *Electric Lift Fuel Pump - Install*.
11. Connect the wire harness connector to the fuel pump module connector (**A**). Press the harness connector onto the module connector until it "clicks."

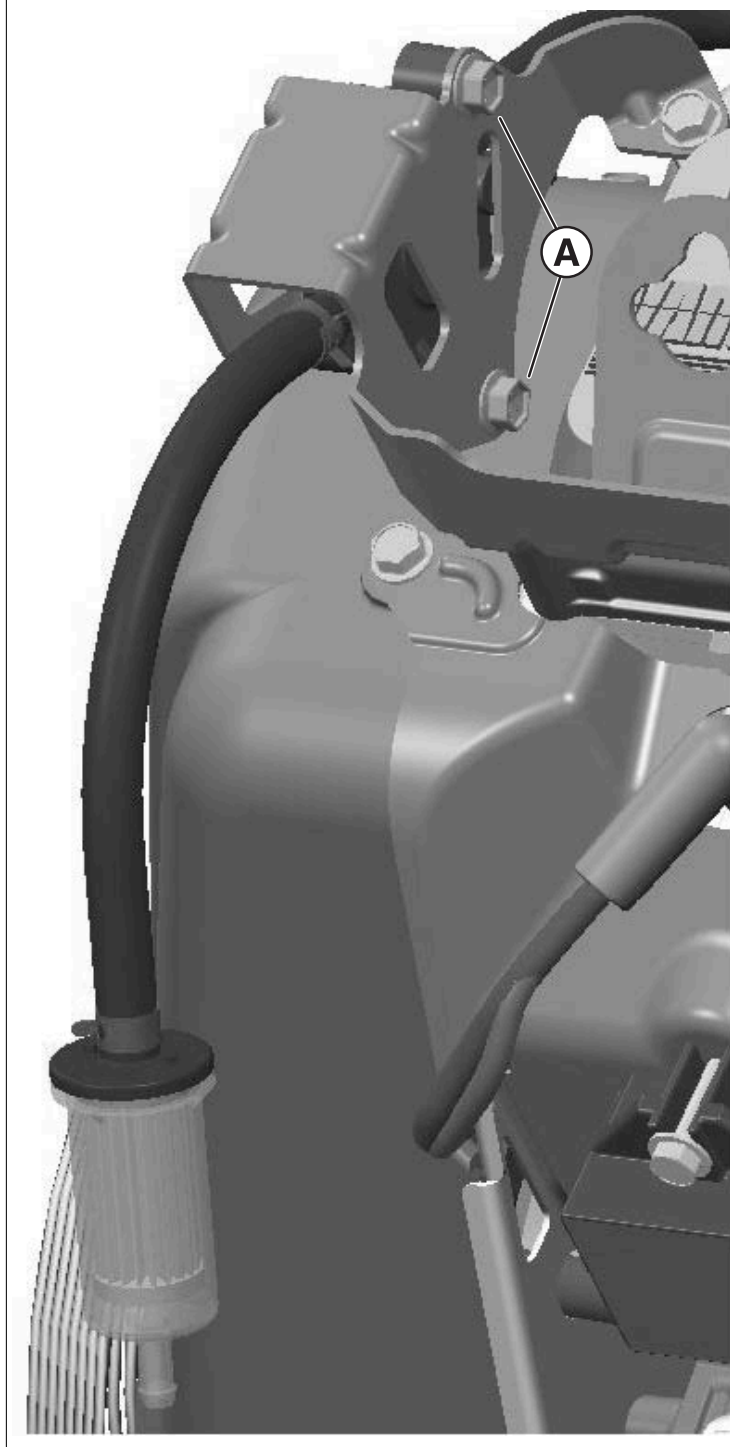
Fuel Pump - Carbureted

1. Install the fuel pump onto the fuel pump bracket.

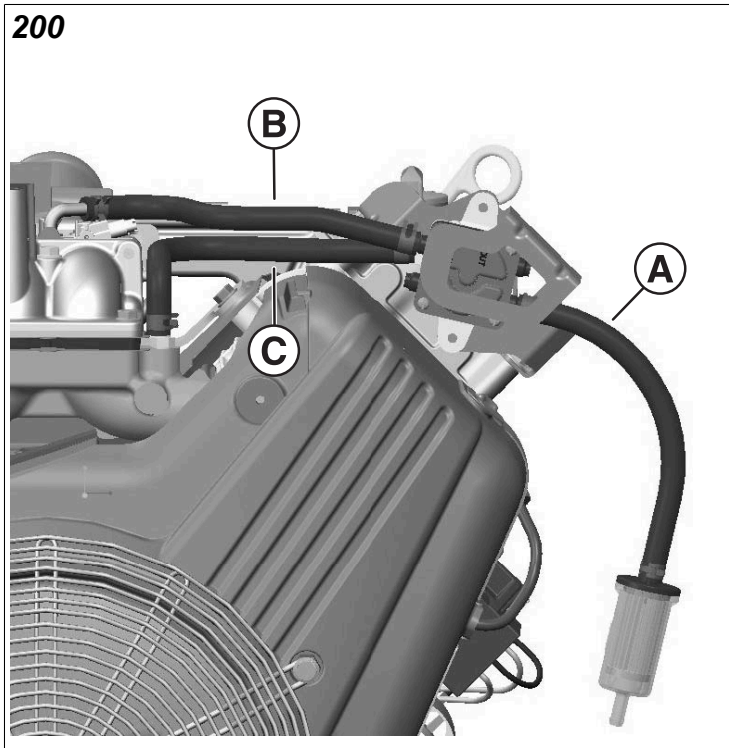
NOTE: The fuel pump has 3 ports, an inlet port which receives fuel from the tank, an outlet port which supplies fuel to the carburetor, and a vent port which vents to the intake manifold. The pump ports will be labeled with "IN" and "OUT" OR have an arrow indicating the direction of fuel flow. Make sure that the lift pump is mounted in the correct orientation and that the outlet port feeds fuel to the carburetor.

2. Start the 2 mounting fasteners by hand (**A**, Figure 199). Tighten to **90 lb-in** (10.2 Nm).

199



3. Install the fuel outlet hose onto the outlet port of the pump (B, Figure 200). Press the hose onto the port, squeeze the tangs of the clamp and slide along the hose until it is positioned on top of the outlet port.



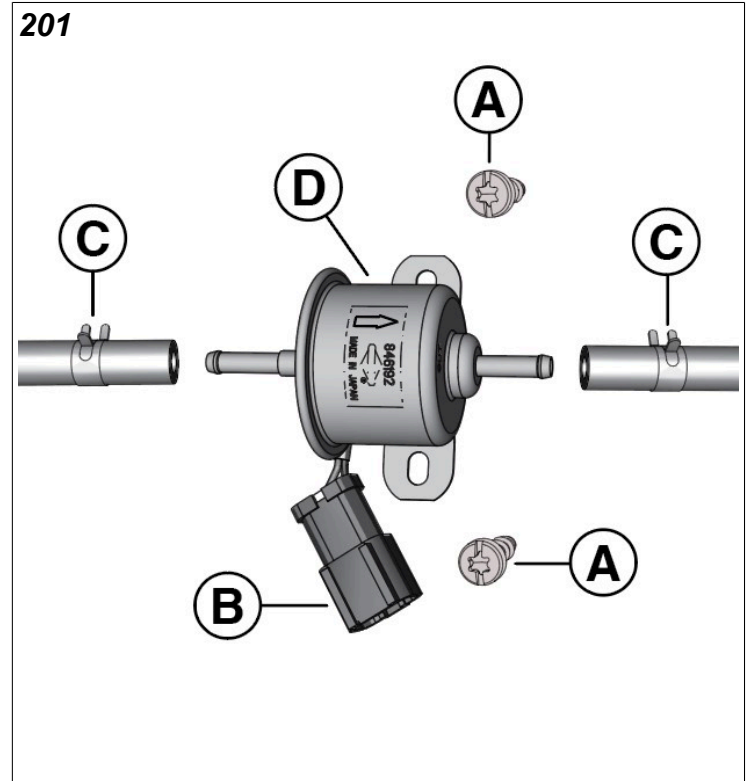
4. Install the other end of the outlet hose onto the fuel inlet port on the carburetor. Press the hose onto the port, squeeze the tangs of the clamp and slide along the hose until it is positioned on top of the inlet port.
5. Install the fuel vent hose onto the vent port of the pump (C). Press the hose onto the port, squeeze the tangs of the clamp and slide along the hose until it is positioned on top of the vent port.
6. Install the other end of the vent hose onto the vent port of the intake manifold. Press the hose onto the port, squeeze the tangs of the clamp and slide along the hose until it is positioned on top of the vent port.
7. Install the fuel inlet hose (A) onto the inlet port of the pump. Press the hose onto the port, squeeze the tangs of the clamp and slide along the hose until it is positioned on top of the inlet port.

Electric Lift Fuel Pump

1. Install the electric lift pump onto the mounting bracket.

NOTE: The electric lift pump has 2 ports, an inlet which receives fuel from the tank, and an outlet which supplies fuel to the fuel pump module. The lift pump ports will be labeled with "IN" and "OUT" OR have an arrow indicating the direction of fuel flow. Make sure that the lift pump is mounted in the correct orientation and that the outlet port feeds fuel to the fuel pump module.

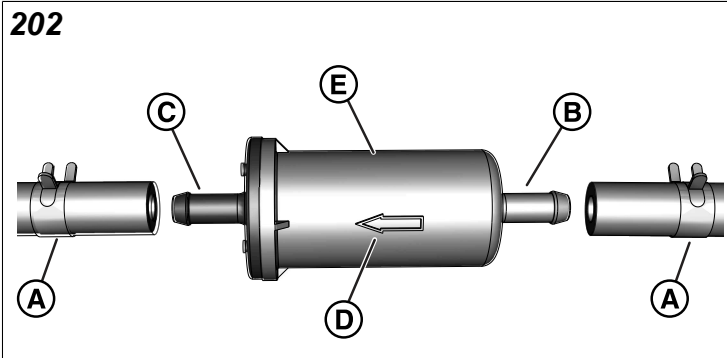
2. Start the 2 mounting fasteners by hand (A, Figure 201). Tighten to **90 lb-in** (10.2 Nm).



3. Install the fuel outlet hose onto the outlet port of the lift pump (D). Press the hose onto the port, squeeze the tangs of the clamp (C) and slide along the hose until it is positioned on top of the outlet port.
4. Connect the other end of the fuel outlet hose to the fuel pump module port. Press the hose onto the port, squeeze the tangs of the clamp and slide along the hose until it is positioned on top of the module port.
5. Connect the fuel inlet hose to the lift pump. Press the hose onto the port, squeeze the tangs of the clamp (C) and slide along the hose until it is positioned on top of the inlet port.
6. Connect the wire harness connector to the lift pump electrical connector (B).

Fuel Filter

1. The inline fuel filter has 2 ports, an inlet port which receives fuel from the tank and an outlet port which feed fuel to the fuel pump. The fuel filter will be labeled with an arrow (D, Figure 202) indicating the direction of fuel flow. You must install the filter in the correct orientation.



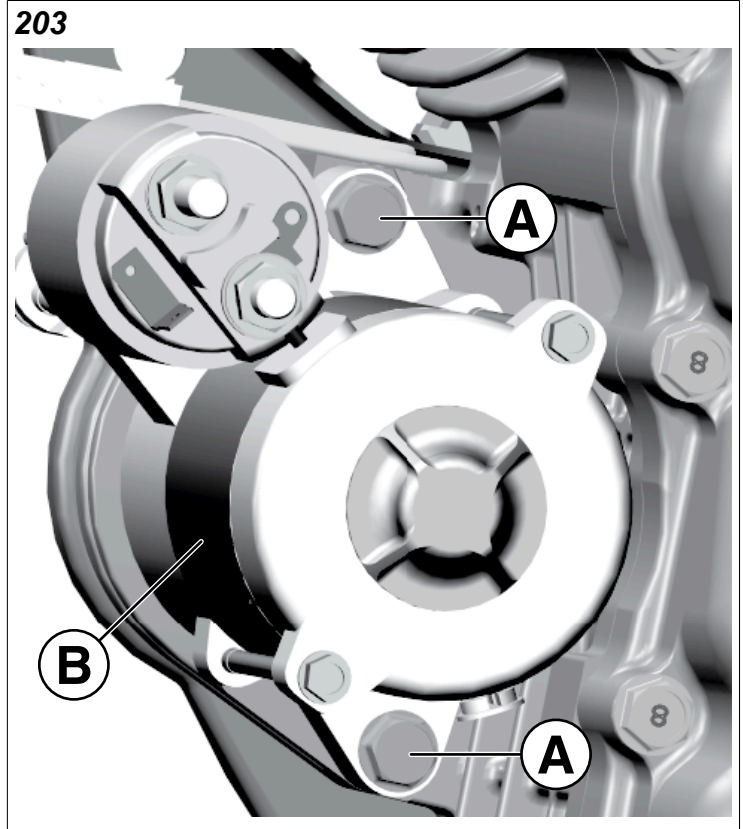
2. Connect the outlet port of the fuel filter to the inlet fuel hose connected to the fuel pump. Press the hose onto the port, squeeze the tangs of the clamp (A) and slide along the hose until it is positioned on top of the outlet port.

NOTE: DO NOT connect the inlet fuel hose until engine is completely assembled and ready to be started. See *Final Instructions*.

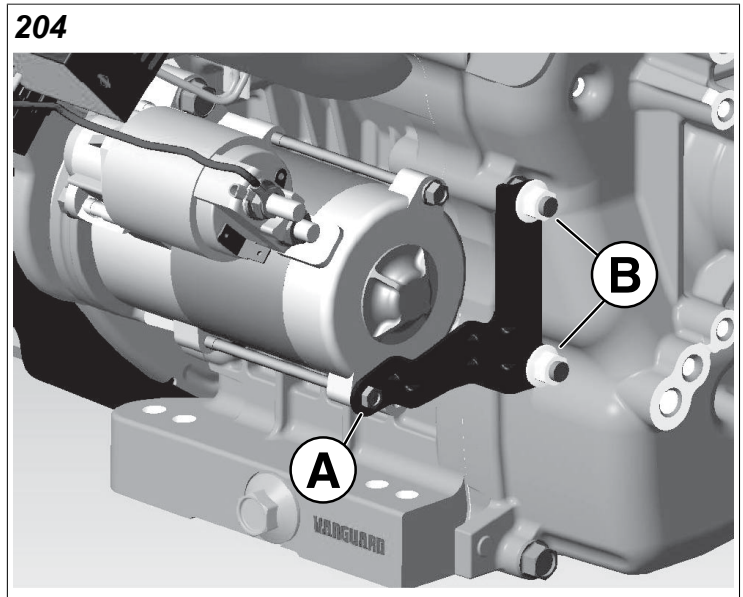
Starter Motor

1. Install the starter motor onto the engine by inserting the starter into the mounting hole. Make sure that the starter pinion gear meshes completely with the flywheel ring gear and that the 2 starter motor fastener mounting holes are properly aligned with the holes on the engine block.

2. Start the 2 mounting fasteners by hand (A, Figure 203). Tighten to **140 lb-in** (15.8 Nm).



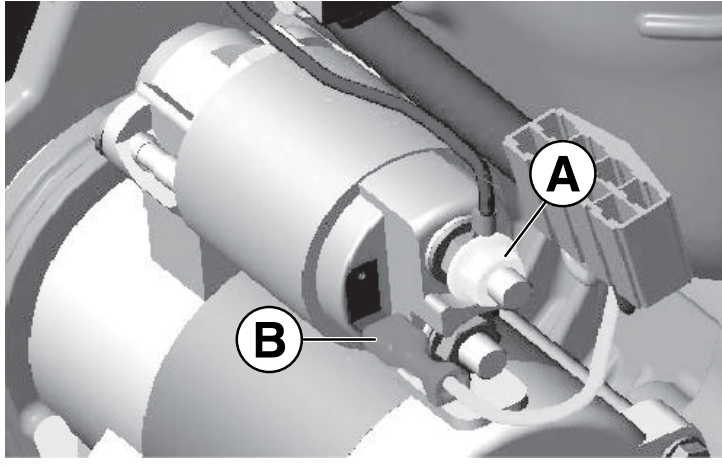
3. If equipped, install the starter motor support bracket to the starter motor and engine block.
4. Start by hand the support bracket to starter motor fastener (A, Figure 204). Tighten to **50 lb-in** (5.6 Nm).



5. Start by hand the 2 support bracket to engine block fasteners (B). Tighten to **195 lb-in** (22 Nm).

6. Connect the ignition switch start wire (B, Figure 205) to the starter motor terminal.

205



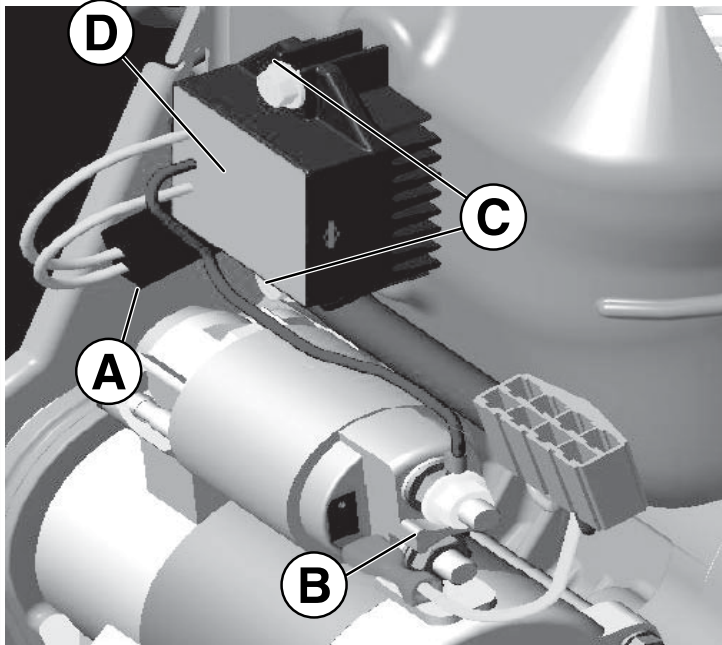
7. Install the voltage regulator wire onto the starter motor positive terminal (A). Start by hand the terminal nut. Tighten to **45 lb-in** (5 Nm).

Voltage Regulator

Your engine may be equipped with either a 20 amp or a 20/50 amp voltage regulator. The 20/50amp voltage regulator has a capacitor mounted to a bracket atop the regulator.

1. Install the regulator into the engine block. Align the regulator mounting holes with the threaded holes in the engine block.
2. Start by hand the 2 mounting fasteners (C, Figure 206). Tighten to **90 lb-in** (10.2 Nm).

206



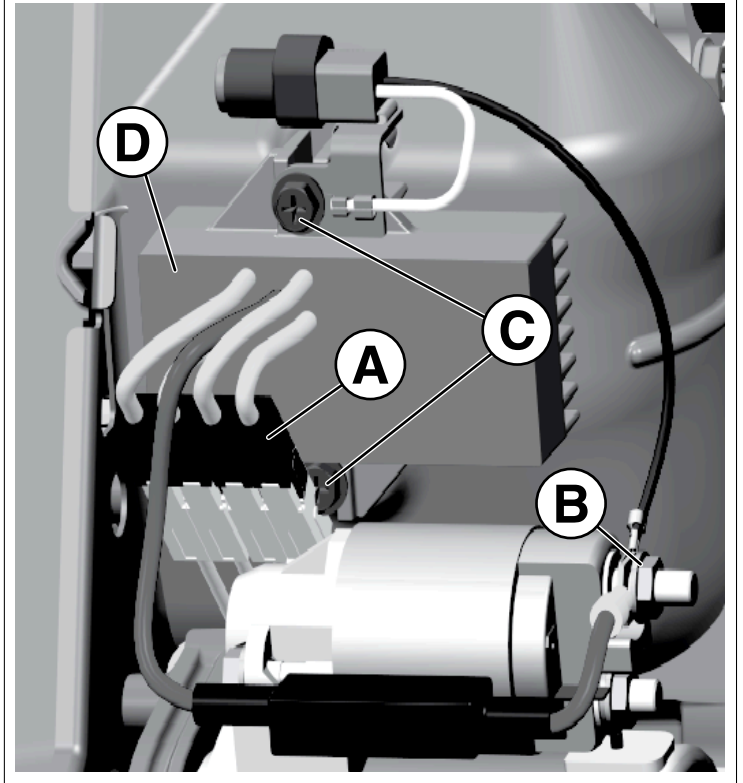
3. Connect the stator wire harness connector to the voltage regulator connector (A).

NOTE: The 20 amp alternator has a single 2-wire connector. The 20/50 amp alternator has double 2-wire connectors.

4. Connect the RED voltage regulator wire with ring terminal connector to the positive starter motor terminal (B).

NOTE: On 20/50 amp alternator equipped engines, an additional wire, from the capacitor, needs to be installed on the starter motor positive terminal. See Figure 207 as a reference.

207

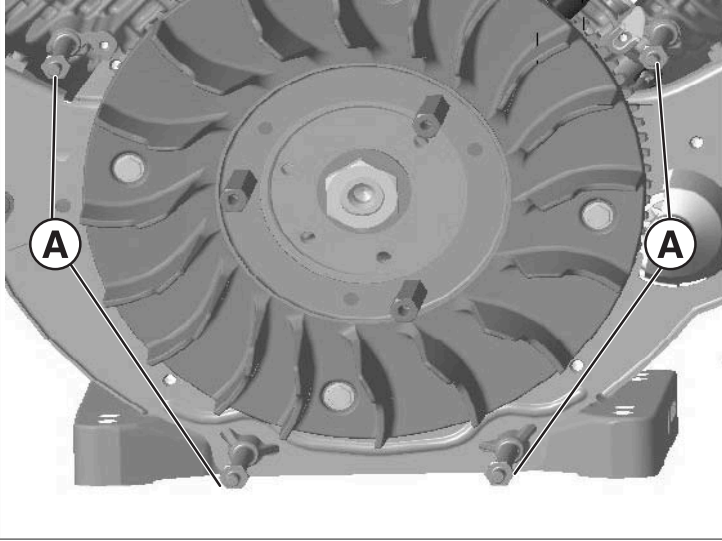


5. Start by hand the starter motor positive terminal nut. Tighten to **45 lb-in** (5 Nm).

Blower Housing

1. If removed during disassembly, install by hand the 4 blower housing mounting posts to the engine block and cylinder heads (**A**, Figure 208). Tighten to **110 lb-in** (12.4 Nm).

208



2. Install the blower housing (**G**, Figure 209) onto the engine. Align the housing mounting holes to the mounting posts on the engine.

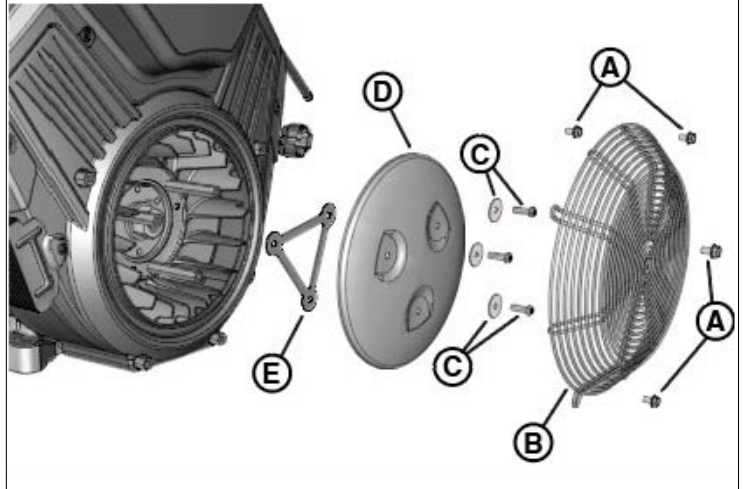
209



3. Start by hand the 4 blower housing coupling nuts (**F**). Tighten to **90 lb-in** (10.2 Nm).

4. Install the triangular spacer (**E**, Figure 210) to the fan mounting posts. Install the debris screen (**D**) atop the triangular spacer. Align the mounting holes of the spacer and screen to the threaded holes of the mounting posts.

210



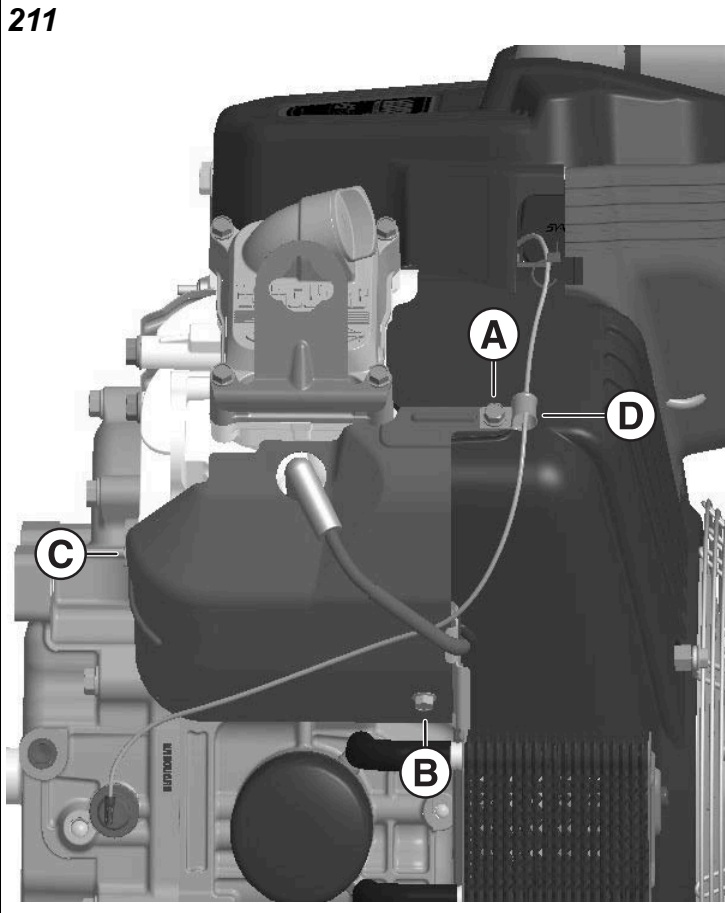
5. Start by hand the 3 mounting fasteners and flat washers (**C**). Tighten to **90 lb-in** (10.2 Nm).
6. Install the wire guard (**B**) to the blower housing by aligning the screen mounting holes to the 4 blower housing coupling nuts.
7. Start by hand the 4 mounting fasteners (**A**). Tighten to **90 lb-in** (10.2 Nm).

Cylinder Air Guides

1. On the oil filter side of the engine, install the cylinder air guide to the cylinder head. Align the air guide mounting holes to the threaded holes in the cylinder head.

NOTE: A wire routing clamp is installed on the top air guide mount. The oil pressure switch wire is secured by the wire clamp and the clamp is secured by the air guide mounting fastener. Install the wire clamp and make sure that the oil pressure switch wire is routed correctly before torquing the fastener.

2. Start by hand the 3 fasteners (**A, B, C**, Figure 211). Tighten to **90 lb-in** (10.2 Nm).

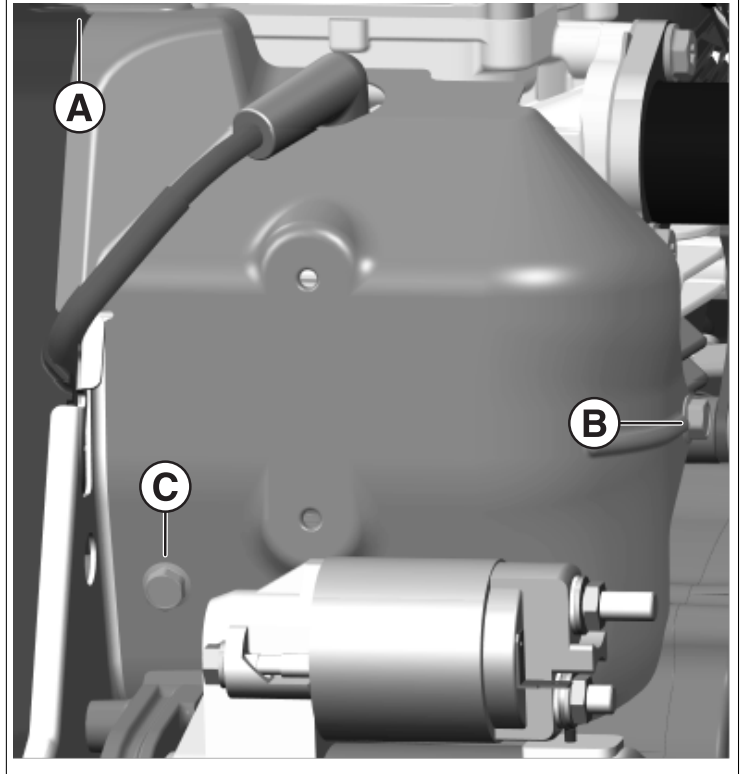


NOTE: A wire routing clamp (**D**) is installed on the top air guide mount. The oil pressure switch wire is secured by the wire clamp and the clamp is secured by the air guide mounting fastener. Install the wire clamp and make sure that the oil pressure switch wire is routed correctly before torquing the fastener.

3. On the starter motor side of the engine, install the cylinder air guide to the cylinder head. Align the air guide mounting holes to the threaded holes in the cylinder head.

4. Start by hand the 3 fasteners (**A, B, C**, Figure 212). Tighten to **90 lb-in** (10.2 Nm).

212

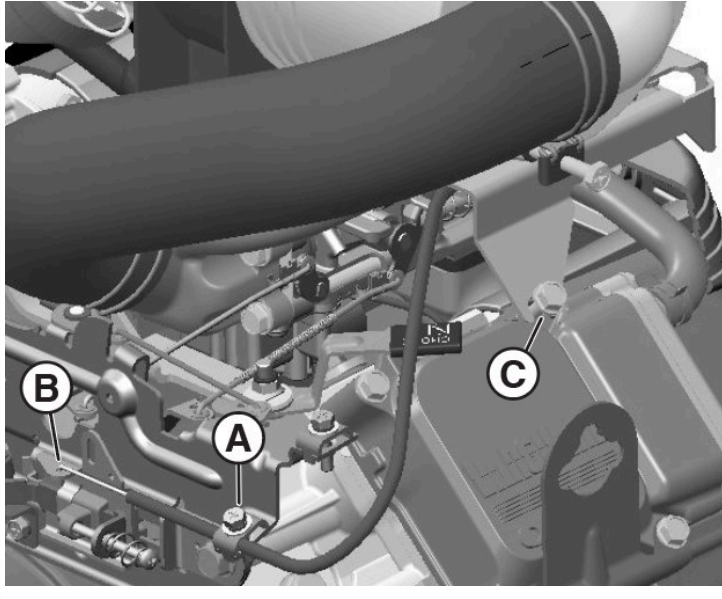


Throttle Control

Depending on your engine's model and trim, a manual detent throttle may be equipped. For engines equipped with a Cyclonic Air Cleaner assembly, the throttle control may be mounted above the key switch cover at the front of the engine. For engines equipped with a Low-Profile Air Cleaner assembly, the throttle control may be remotely mounted. For engine mounted throttle controls, proceed as follows. For remote mounted throttle control, see your equipment's repair manual for installation instructions.

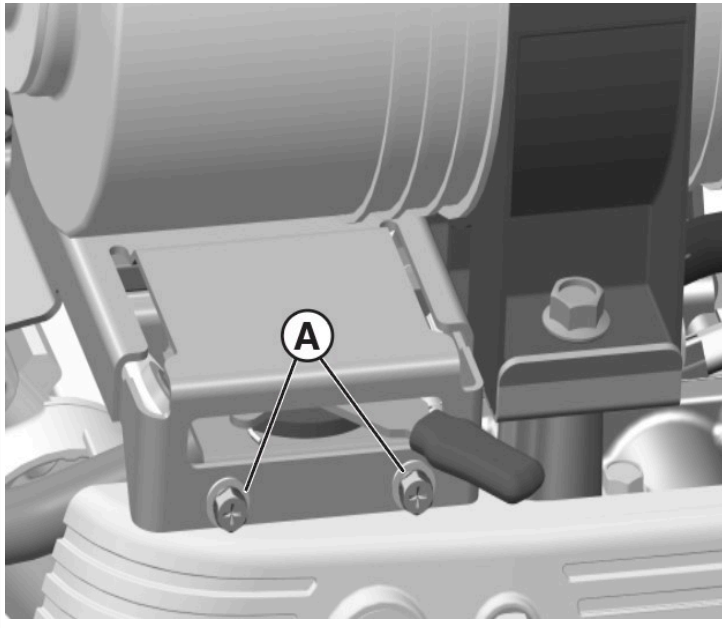
1. Insert the "Z" bend of the throttle cable (**B**, Figure 213) into the hole in the speed control bracket tab.

213



2. Route the throttle cable through the cable clamp (**A**) on the speed control bracket. Install fastener and tighten to **23 lb-in** (2.6 Nm).
3. Install the throttle control into the support bracket and start the 2 fasteners (**A**, Figure 214) by hand. Tighten fasteners to **35 lb-in** (4 Nm).

214



NOTE: The support bracket that houses the throttle control also serves as the air cleaner support bracket. This bracket is secured, on one side, with a valve cover fastener (**C**, Figure 213). Tighten fastener to **90 lb-in** (10.2 Nm).

Engine Covers

There are 2 engine covers, which are identified here as the key switch cover and the air intake elbow cover.

The key switch cover serves as the housing for the ignition key switch and/or throttle lever, if equipped, and is always fastened to the blower housing. The air intake elbow cover has a contoured opening to accommodate the air intake elbow, and is variously fastened to other bracketry or components, such as the fuel pump module bracket, air cleaner bracket, air intake elbow, etc.

The air intake elbow cover is absent on those models equipped with the low profile air cleaner.

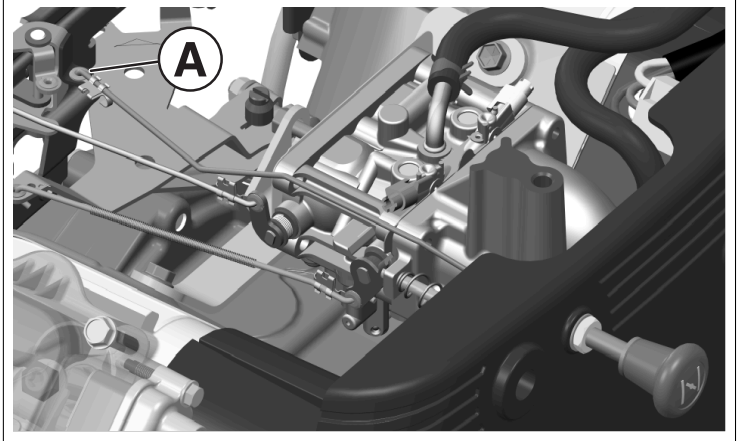
Cover appearance may differ based on model and/or options.

Key Switch Cover

NOTE: Depending on your engine's model, trim and type, a number of throttle lever options exist. If your engine is equipped with a rotary-style throttle lever, and a push-pull choke, proceed as follows. If your engine is equipped with a detent-style throttle lever, see *Throttle Control* in this section.

1. If your engine is equipped with choke and throttle controls, proceed as follows:
2. Insert the push/pull choke lever into the mounting hole of the cover, see Figure 215.

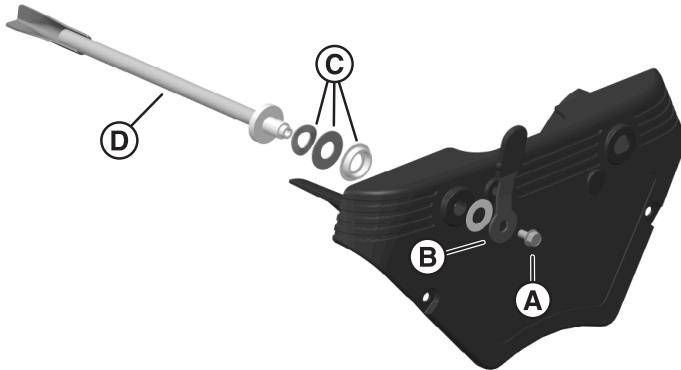
215



3. Start by hand the jamb nut on the threaded shaft of the choke knob on the inside of the cover. Tighten to **33 lb-in** (3.7 Nm).

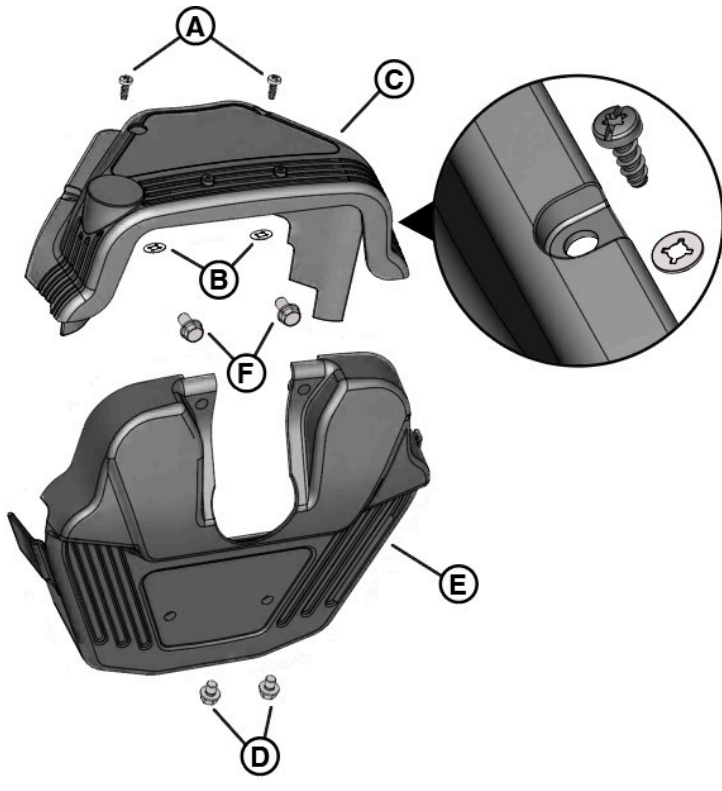
4. If equipped with a manual rotary throttle lever, install the throttle lever (**B**, Figure 216) with fastener (**A**) and washer stack (**C**) to the throttle shaft (**D**). Tighten to **90 lb-in** (10.2 Nm).

216



5. Install the key switch cover (**C**, Figure 217) onto the engine atop the blower housing.
6. Connect the choke rod to the speed control bracket by inserting the end of the rod into the bushing hole (**A**, Figure 215). Attach the retaining clip to the choke rod.
7. Connect the throttle control shaft (**D**, Figure 216) to the speed control bracket by pushing the shaft into the bracket groove until captured.
8. Start by hand the 2 cover fasteners and retaining washers (**A-B**, Figure 217). Tighten to **30 lb-in** (3.4 Nm).

217



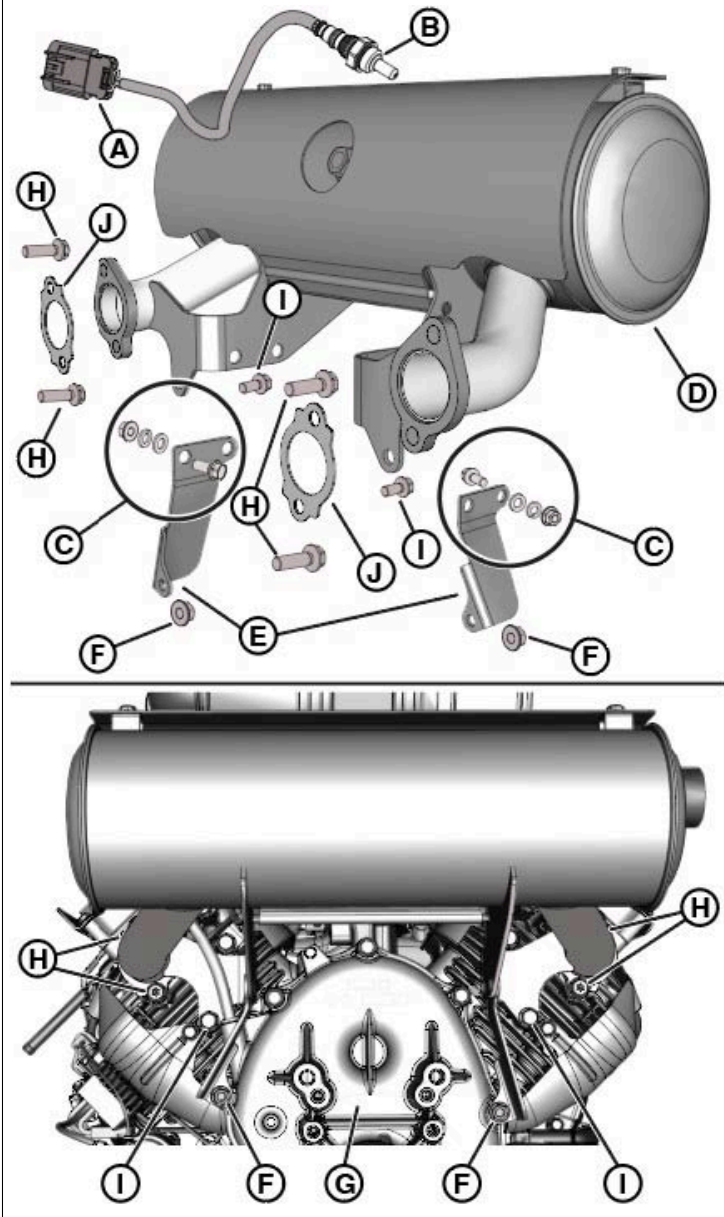
Intake Elbow Cover

1. If equipped, connect MIL/tachometer/hourmeter harness connector to component connector on the back of the cover.
2. Install air intake elbow cover (**E**, Figure 217) atop the engine. Align the mounting holes to the threaded mounting holes of the support brackets.
3. Start by hand the 2 cover fasteners that connect the cover to the air cleaner bracket (**F**). Tighten to **90 lb-in** (10.2 Nm).
4. Start by hand the 2 cover fasteners that connect the cover to the fuel pump module bracket (**D**). Tighten to **90 lb-in** (10.2 Nm).

Muffler

1. If equipped with optional muffler bracket support, proceed as follows:
 - A. Install 2 fasteners (F, Figure 218) to fasten bracket supports (E) to crankcase cover () studs. Tighten to **195 lb-in** (22 Nm).
 - B. Install fastener, flat washer, lock washer, and hex nut (C) to fasten muffler (D) bracket to bracket supports. Tighten nuts to **195 lb-in** (22 Nm).

218



2. Verify that exhaust manifold and cylinder head flanges are clean and dry. Install **new** gaskets (J) onto exhaust manifold flanges.

3. Apply anti-seize compound to threads of 4 fasteners (H), and then install to fasten muffler manifolds to cylinder heads. Tighten fasteners to **195 lb-in** (22 Nm).

NOTE: Depending on your engine model and trim, the muffler manifold to cylinder head fastener may be replaced with studs and nuts. Apply anti-seize compound to threads of studs and tighten nuts to **195 lb-in**(22 Nm).

4. Install 2 fasteners (I) to fasten muffler bracket to crankcase. Tighten screws to **195 lb-in** (22 Nm).
5. If removed, rotate sensor body hex clockwise to fasten O₂ sensor (B) to muffler. Tighten sensor to **160 lb-in** (18 Nm).
6. Connect O₂ sensor connector (A).

Air Cleaner Assembly - Cyclonic

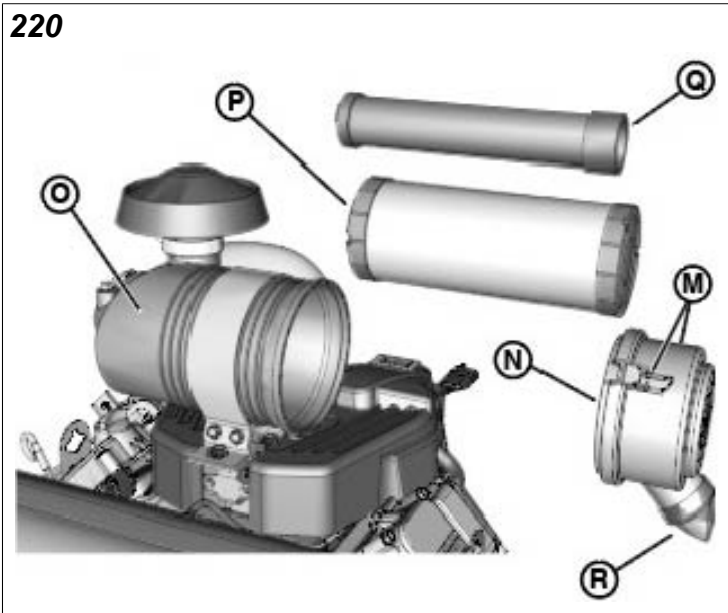
1. Install 2 fasteners (A, Figure 219) to secure air cleaner bottom bracket (B) to fuel pump module bracket support. Tighten to **138 lb-in** (15.6 Nm).

219



2. Install fastener (C) to secure air cleaner bottom bracket to air intake elbow. Tighten to **90 lb-in** (10.2 Nm).
3. If equipped, connect MIL/tachometer/hourmeter connector (D) at back of top cover (E).
4. Install 4 fasteners (F) to secure top cover to air intake elbow and air cleaner bottom bracket. Alternately tighten to **90 lb-in** (10.2 Nm).
5. Install 2 fasteners (G) to secure air cleaner top bracket (H) to air cleaner bottom bracket. Tighten to **138 lb-in** (15.6 Nm).

6. Position air cleaner assembly (I) on air cleaner top bracket with the duckbill air valve pointing down.
7. Engage hook on air cleaner strap (J) with lip on air cleaner top bracket.
8. Install 2 fasteners (K) to secure air cleaner strap to air cleaner top bracket. Tighten to **90 lb-in** (10.2 Nm).
9. If detached, install hose onto air outlet elbow with the paint mark on top. Install band clamp at end of hose and tighten to **35 lb-in** (4 Nm).
10. Loosely install band clamp (L) at opposite end of hose, and install hose onto air intake elbow. Tighten band clamp to **18 lb-in** (2 Nm).
11. Disengage 2 retaining clips (M, Figure 220) to release air cleaner cover (N) from air cleaner base (O).



12. Remove air filter (P) from air cleaner base.
 13. Remove safety filter (Q) from air cleaner base, if equipped.
 14. Gently tap air filter on a hard surface to remove dust, dirt and debris. Carefully brush and/or vacuum air filter as necessary.
- NOTE:** Use of pressurized air or solvents will damage air filter.
15. Carefully inspect air filter, and replace if it cannot be adequately cleaned or if any damage is observed.
 16. Inspect seal in air cleaner base for cuts, tears, holes, or general deterioration. Replace as necessary.
 17. Use a soft bristle brush and a portable hand vacuum to remove all dust and dirt from air cleaner cover and air cleaner base.

NOTE: Exercise care to keep dust and dirt out of hose to air intake elbow. Inadequate precautions can result in engine damage.

18. If equipped, install safety filter into air cleaner base. Orient the safety filter so that the open end installs into the base.

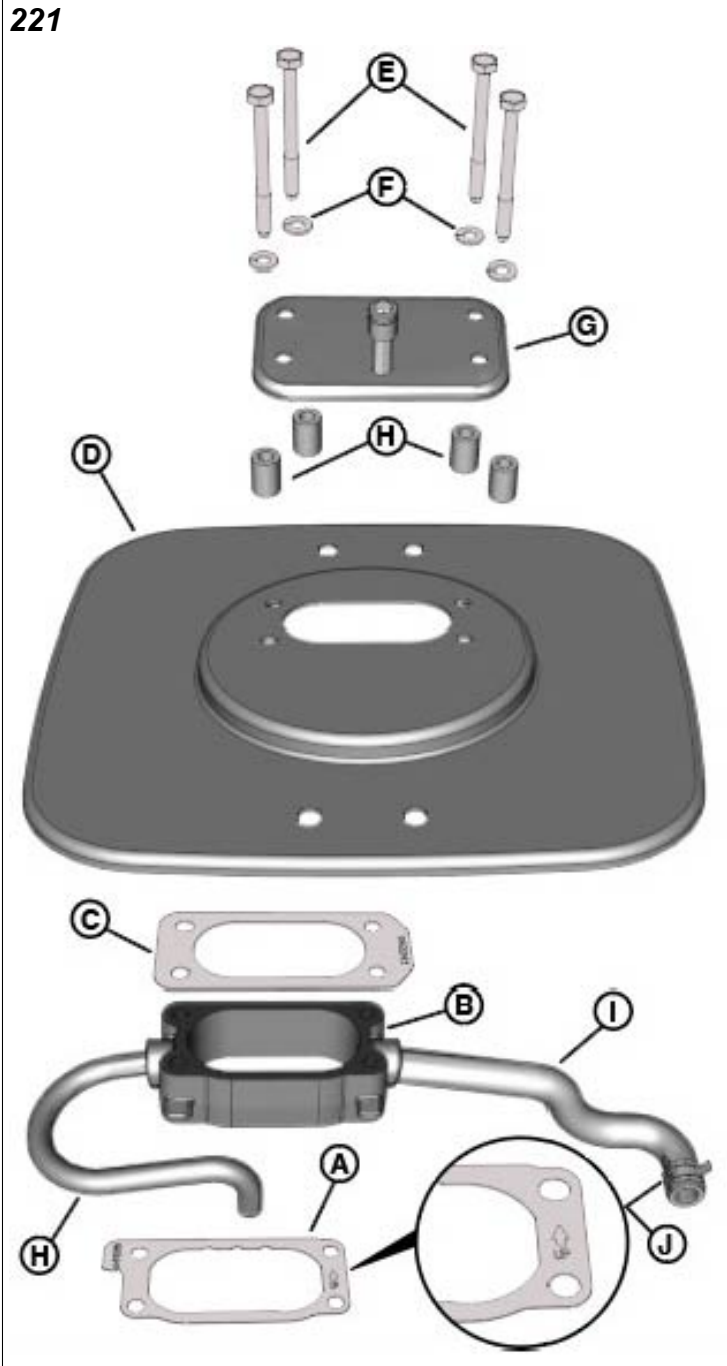
NOTE: Replace the safety filter with every third air filter replacement.

19. Install air filter into air cleaner base.
20. Install air cleaner cover onto air cleaner base and engage two retaining clips to secure.
21. Inspect duckbill air valve (R) on air inlet port of air cleaner cover. Look for cuts, tears, holes, or general deterioration. Replace duckbill air valve if damaged or missing.

NOTE: Engine operation without the duckbill air valve can reduce filter efficiency by as much as 50 percent.

Air Cleaner Assembly - Low Profile

1. Position throttle body gasket (A, Figure 221) at top of throttle body. Verify that gasket surfaces are clean and dry before installation.



NOTE: Be sure UP arrow is at the top and points toward the MAG bearing side (white part number stamp on the starter motor side).

2. Install throttle body adapter (B) on top of gasket. Verify that gasket surfaces are clean and dry before installation.
3. Install gasket (C) at top of throttle body adapter.

NOTE: Be sure red part number stamp is at the top on the oil filter side.

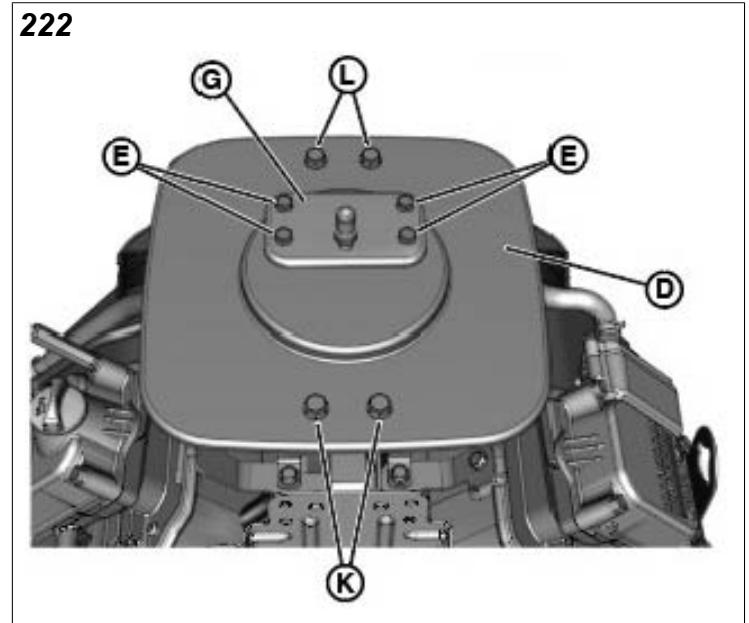
4. Install back plate (D) at top of throttle body adapter gasket.

NOTE: Note that back plate is stamped "Air Filter Side" to ensure proper installation.

5. Install 4 fasteners (E) with lock washers (F) to secure carburetor shield (G), spacers (H), back plate, throttle body adapter gasket, throttle body adapter, and throttle body gasket to throttle body. Tighten to **90 lb-in** (10.2 Nm) using a crosswise pattern.

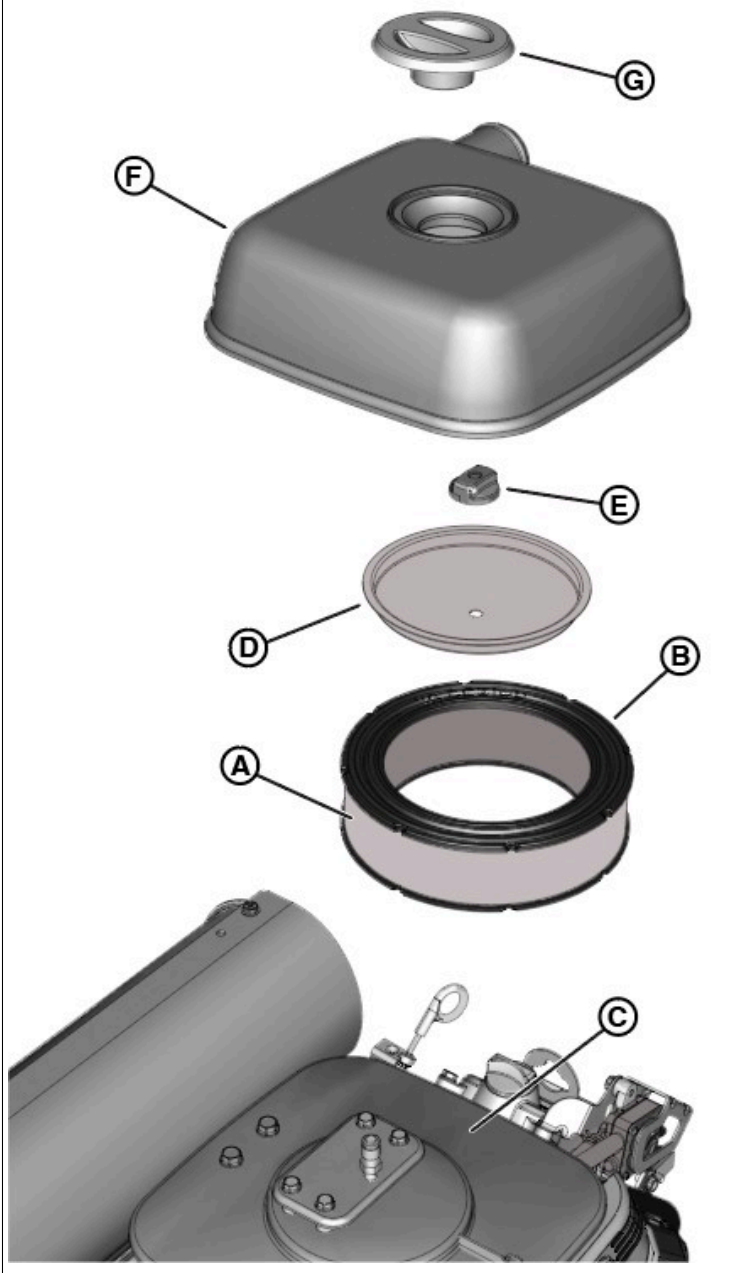
NOTE: Be sure carburetor shield is oriented, so that the threaded stud is on the fuel pump module bracket side.

6. Inspect breather hose (H) and EVAP hose (I) for dryness, cracking, flaking, splits, or general deterioration. Replace if necessary.
7. Install breather hose onto valve cover fitting.
8. Install EVAP hose onto fuel pump module fitting. Squeeze tangs and move hose clamp (I) about **1/8 inch** (3 mm) from end of hose.
9. Install fasteners (K, Figure 222) to secure back plate to fuel pump module bracket. Install fasteners (L) to secure back plate to ECM/fuse block bracket. Tighten to **115 lb-in** (13 Nm) using a crosswise pattern.



- Remove foam pre-cleaner (A, Figure 223) from air filter (B).

223



- Gently tap air filter on a hard surface to loosen dirt and debris. Carefully clean with a soft bristle brush and a portable hand vacuum as necessary.
- Use a soft bristle brush and a portable hand vacuum to remove all dust and dirt from back plate, metal retainer plate, and air filter cover.

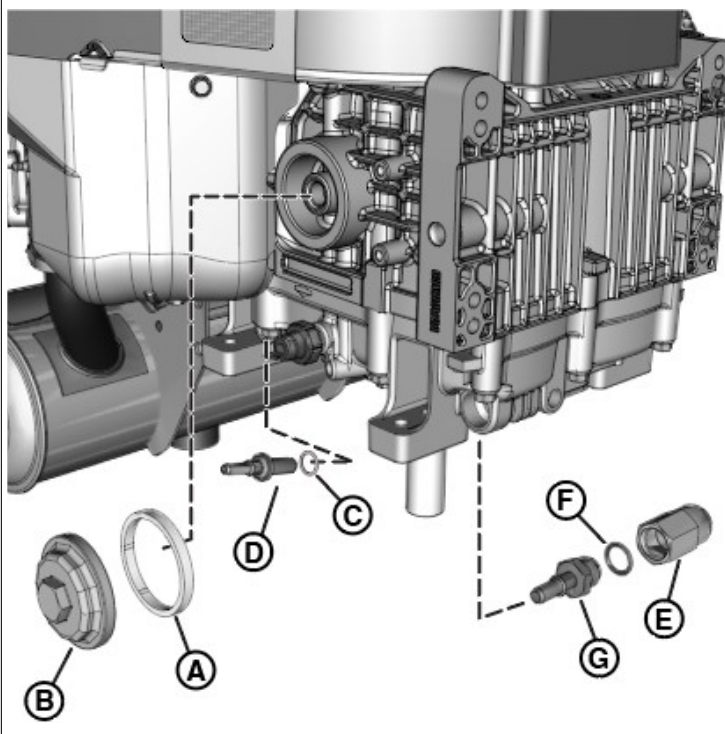
NOTE: Exercise care to keep dust and dirt out of air intake. Inadequate precautions can result in engine damage.
- Gently wash foam pre-cleaner in warm, soapy water. Thoroughly rinse with clean water and allow to air dry completely.
- Carefully inspect foam pre-cleaner and air filter. Replace parts if they cannot be adequately cleaned or if any damage is observed.

- Install foam pre-cleaner onto air filter.
- Place air filter with foam pre-cleaner onto air cleaner back plate (C).
- Fit metal retainer plate (D) evenly and snugly into air filter.
- Install thumb nut (E) onto threaded rod and tighten until snug.
- Install air filter cover (F).
- Install plastic cap (G) to secure air filter cover and tighten until snug.

Optional Oil Guard System

- Install oil bypass cover as follows:
 - Apply a thin film of clean engine oil to seal ring (A, Figure 224). Install seal ring into groove on bypass cover (B).
 - Hand start bypass cover into crankcase bore. Be sure seal ring is not pinched when it first contacts crankcase.
 - Tighten bypass cover to **165 lb-in** (18.6 Nm).
 - Using an absorbent cloth, wipe up any residual oil from around cover.

224



2. Install oil scavenge hose fitting and hose as follows:
 - A. Apply a light film of clean engine oil to **new** o-ring (**C**) of oil scavenge pump hose fitting (**D**). Install o-ring onto fitting.

NOTE: Verify that old o-ring is not present in the crankcase cover bore. Inadvertently stacking old and new o-rings will result in oil leaks.

- B. Install oil scavenge pump hose fitting into crankcase cover bore closest to the cylinder heads, and hand tighten until snug. Tighten hose fitting to **215 lb-in** (24.3 Nm).
 - C. Install oil scavenge hose connector (with red clip lock) onto fitting. Push in clip lock to secure.
3. Install crankcase ventilation hose connector (with blue clip lock) onto fitting. Push in clip lock to secure.
4. Install oil supply check valve, hose fitting, and hose as follows:
 - A. Install oil supply check valve (**E**) into crankcase cover bore farthest from the cylinder heads. Tighten check valve to **375 lb-in** (42.4 Nm).
 - B. Apply a light film of clean engine oil to **new** o-ring (**F**) of oil supply pump hose fitting (**G**). Install o-ring onto fitting.

NOTE: Verify that old o-ring is not present in the check valve bore. Inadvertently stacking old and new o-rings will result in oil leaks.

- C. Install hose fitting into check valve and tighten to **325 lb-in** (36.7 Nm).

5. Prime oil supply pump as follows:

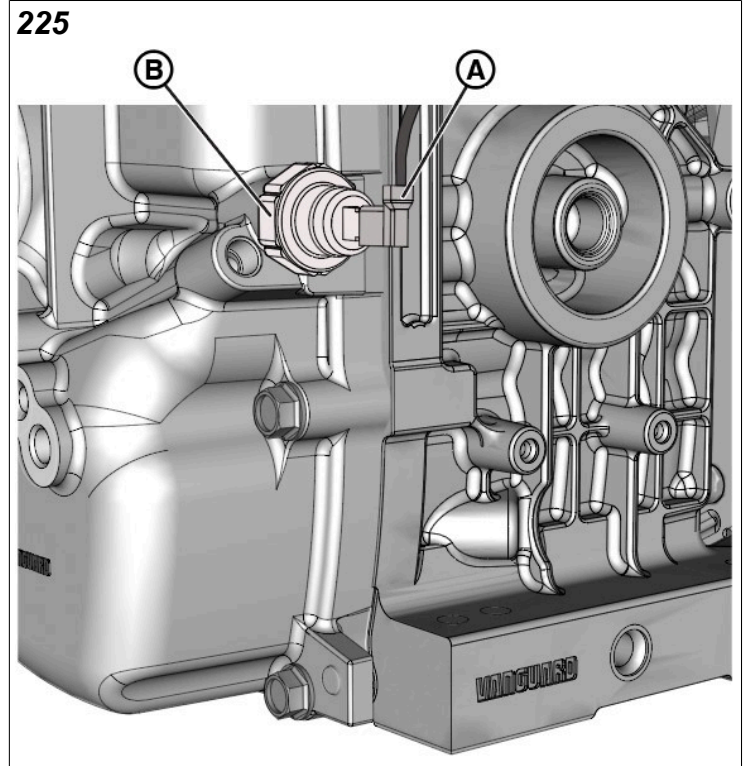
NOTE: Failure to prime oil supply gerotor pump will result in air pockets in the lubrication system and can lead to catastrophic engine damage.

- A. If available, obtain green rubber cap used to keep dust and dirt out of fitting during shipping. Install rubber cap onto fitting to act as an oil seal during priming.
- B. Obtain standard oil can with a pointed nozzle. Verify that nozzle is clean of dirt and grit, and then push through rubber cap.
- C. Add **3 ounces** (88.7 ml) of oil. Remove and discard rubber cap.
- D. Install oil supply hose connector (with green clip lock) onto fitting. Push in clip lock to secure.

Oil Pressure Switch

1. Thoroughly clean the threads of the oil pressure switch to remove any dirt or debris.
2. Snugly wrap thread sealing tape around the threads of the switch 2-3 times in a counter-clockwise direction.

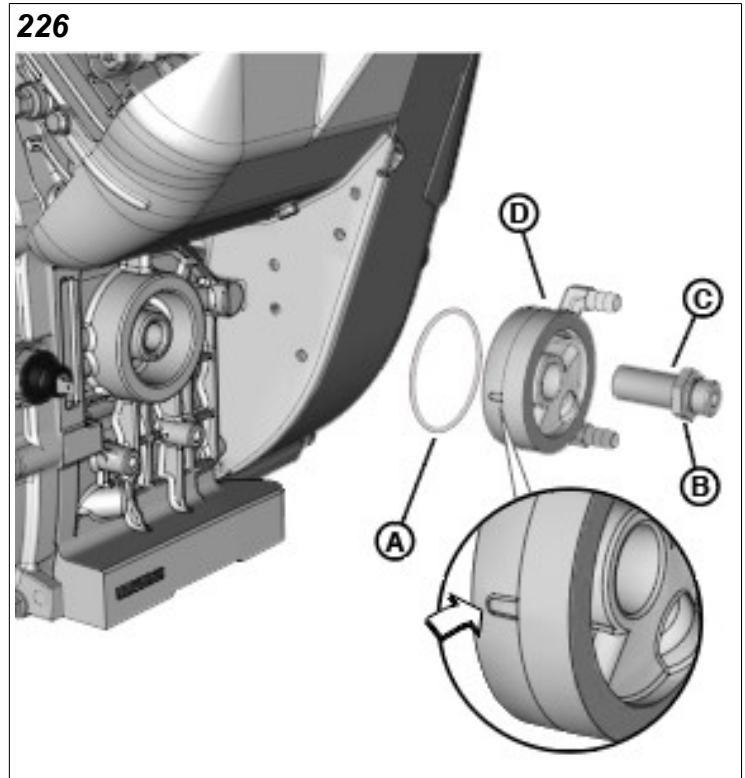
3. Start by hand the switch (**B**, Figure 225) into the crankcase. Tighten to **15 lb-in** (1.7 Nm).



4. Connect the harness spade connector (**A**) to the switch spade contact.

Oil Diverter Valve and Drip Tray

1. Inspect o-ring (**A**, Figure 226) in diverter groove for cuts, tears, or general deterioration. Install **new** o-ring, if necessary.

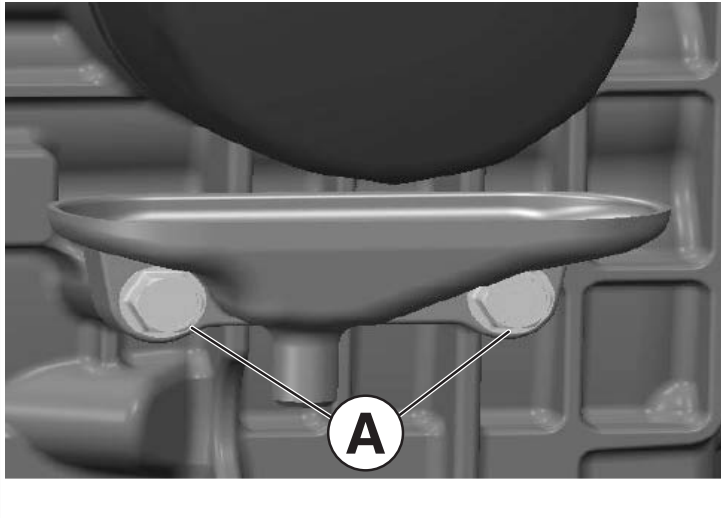


2. Rotate hex (B) to install adapter (C) and diverter (D) to crankcase flange.

NOTE: Orient diverter so that the locator tab faces toward the PTO side crankcase cover side as shown.

3. Tighten adapter to **240 lb-in** (27.1 Nm).
4. If equipped, install the optional drip tray onto the crankcase bosses beneath the oil filter.
5. Start by hand the 2 drip tray fasteners (A, Figure 227). Tighten to **70 lb-in** (7.9 Nm).

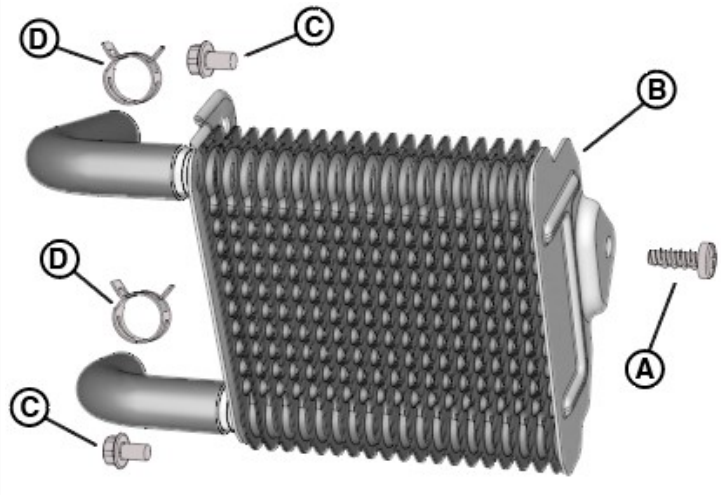
227



Oil Cooler

1. Install the oil cooler inlet and outlet hoses onto the diverter valve oil fittings. Squeeze the tangs of the hose clamps (D, Figure 228) and slide clamps along the hose until positioned over the diverter valve oil fittings.

228

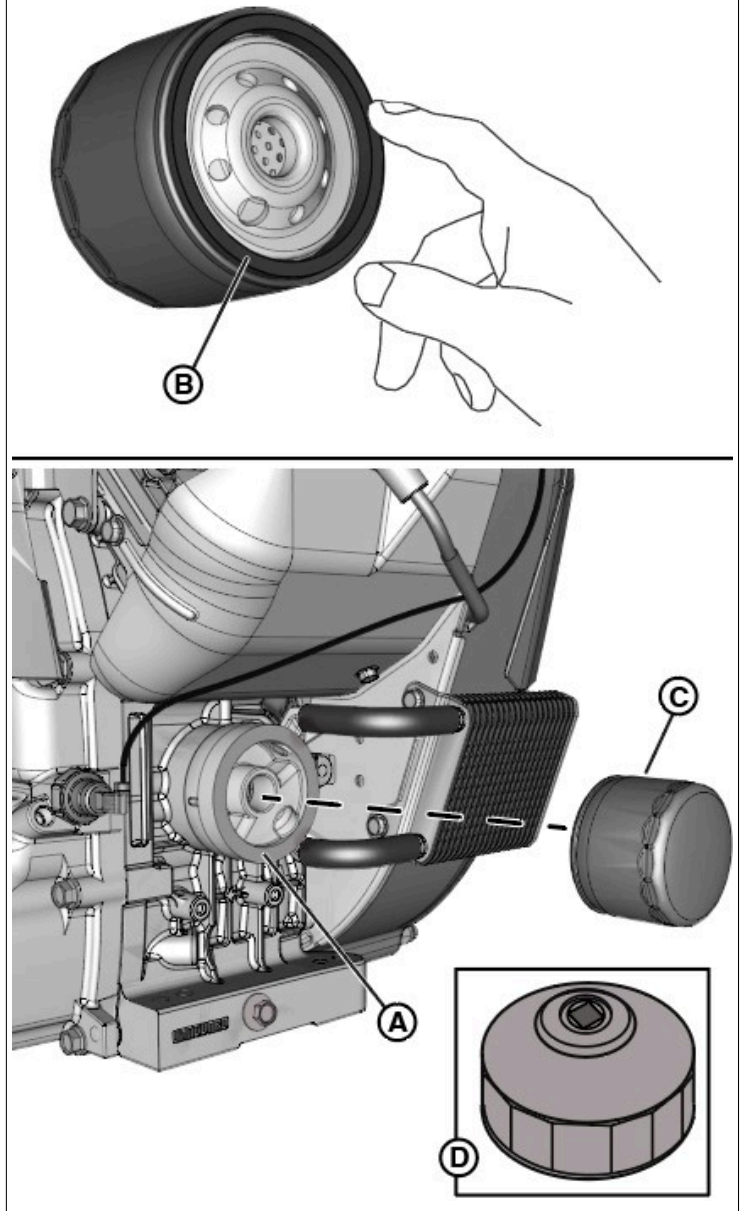


2. Install 2 fasteners (C) to secure the oil cooler bottom bracket to the engine back plate.
3. Install the fastener (A) to secure the oil cooler top bracket (B) to the blower housing.

Oil Filter

1. Verify the oil filter mount flange (A, Figure 229) is clean and dry.

229



2. Lubricate gasket of **new** oil filter with a thin film of clean engine oil (B).
3. Install oil filter (C), and hand tighten until gasket contacts filter mount flange. Using a 76mm-14 Flute end cap style oil filter wrench (D) with ratchet and extension bar, tighten oil filter to **75 lb-in** (8.5 Nm). Do not use air tools.

Final Instructions

Prior to the operation of the engine after completion of any service and repair procedures, you must obey all safety messages contained in *SECTION 1 - SAFETY AND GENERAL INFORMATION - General Safety Messages*.

1. Install oil drain plug with sealing washer by hand. Tighten as follows:

Oil Drain Plug		
Engine	Plug Type	Torque
Horizontal and Vertical Shaft	Metric (C1 in Figure 3)	240 lb-in (27.1 Nm)
	NPTF (C2 in Figure 3)	128 lb-in (14.5 Nm)
Oil Guard Equipped Engine, Drain Plug Installed on Crankcase Cover	NPTF (C2 in Figure 3)	125 lb-in (14.1 Nm)

2. Add engine oil. See *SECTION 2 - MAINTENANCE - Check Engine Oil Level/Change Engine Oil/Replace Oil Filter*. If your engine is equipped with the Oil Guard System, see *SECTION 2 - MAINTENANCE - Check/Change Engine Oil/Replace Oil Filter on Vanguard Oil Guard System*.

NOTE: If equipped with Vanguard Oil Guard System, make sure that the system is properly primed prior to operation. See this section, *Optional Oil Guard System* step 5.

3. Install spark plug wires onto spark plug terminals.
4. Connect the outlet fuel hose of the fuel tank to the inlet fuel port of the inline fuel filter. Press the hose onto the port, squeeze the tangs of the clamp and slide along the hose until it is positioned on top of the inlet port.
5. Fill fuel tank with fresh gasoline.
6. Start and run the engine. Check for fuel and oil leaks while engine is running.
7. Adjust idle speed. See *SECTION 2 - MAINTENANCE - Idle Speed Adjustment*.
8. Adjust high speed/top no-load speed. See *SECTION 2 - MAINTENANCE - High Speed Adjustment*.
9. Adjust Throttle Position Sensor (TPS). See *Throttle Position Sensor - Adjustment* in this section.

SECTION 9 - SPECIFICATIONS

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SPECIFICATIONS

Engine Specifications - 610000

ENGINE	6114, 6134-37	6132-3	61H	61A	61E	61G
Fuel Type and System	Gasoline - Carburetor	Gaseous - Mixer	Gaseous - Mixer	Gasoline - EFI-ETC	Gasoline - EFI	Gasoline - EFI-ETC
Bore	3.366 in (85.5 mm)					
Stroke	3.405 in (86.5 mm)					
Displacement	60.6 ci (993 cc)					
Compression Ratio	8.2:1	8.5:1 or 9.7:1		8.2:1		8.5:1
Crankshaft End Play	With Crankcase Cover Silicone Sealant Bead: 0.004-0.017 in (0.009-0.44 mm)					
	With Crankcase Cover Steel Core Gasket: 0.015-0.039 in (0.39-1.00 mm)					
Oil Capacity	78-80 oz (2.3-2.4 L)					
Oil Capacity - Oil Guard	6137 - 160 oz (4.7 L)			61A6 - 160 oz (4.7 L)	61E8/9 - 160 oz (4.7 L)	61G9 - 160 oz (4.7 L)
Armature Air Gap	0.005-0.012 in (0.13-0.30 mm)					
CKP Sensor Air Gap				0.010 in (0.25 mm)		
Spark Plug Gap	0.030 in (0.076 mm)	0.020 in (0.51 mm)		0.030 in (0.076 mm)		
Valve Clearance - Intake	0.004-0.006 in (0.10-0.15 mm)					
Valve Clearance - Exhaust	0.007-0.009 in (0.18-0.23 mm)					
Crankcase MAG Bearing Oil Seal Depth	Flush to 0.040 in (0-1.0 mm)					
Crankcase Cover PTO Bearing Oil Seal Depth	0.040-0.080 in (1.0-2.0 mm)					

Engine Specifications - 540000

ENGINE	5404	5414-17, 5124-27	5434-37	54E1	54E6
Fuel Type and System	Gasoline - Carburetor			Gasoline - EFI	
Bore	3.37 in (85.6 mm)				
Stroke	3.07 (77.98 mm)				
Displacement	54.7 ci (896 cc)				
Compression Ratio	8.2:1				
Crankshaft End Play	With Crankcase Cover Silicone Sealant Bead: 0.004-0.017 in (0.09-0.44 mm)				
	With Crankcase Cover Steel Core Gasket: 0.015-0.039 in (0.39-1.00 mm)				
Oil Capacity	78-80 oz (2.3-2.4 L)				
Oil Capacity - Oil Guard		5417 - 160 oz (4.7 L)	5437 - 160 oz (4.7 L)		160 oz (4.7 L)
Armature Air Gap	0.005-0.012 in (0.13-0.30 mm)				
CKP Sensor				0.010 in (0.25 mm)	
Spark Plug Gap	0.030 in (0.76 mm)				
Valve Clearance - Intake	0.004-0.006 in (0.10-0.15 mm)				
Valve Clearance - Exhaust	0.007-0.009 in (0.18-0.23 mm)				
Crankcase MAG Bearing Oil Seal Depth	Flush to 0.040 in (0-1.0 mm)				
Crankcase Cover PTO Bearing oil Seal Depth	0.040-0.080 in (1.0-2.0 mm)				

Engine Parameter Specifications - 540000 and 610000

ENGINE PARAMETER	MODEL 540000	MODEL 610000
Fuel Pressure - EFI and EFI-ETC Engines	38-43 PSI (262-296 kPa)	
Oil Pressure	10-50 PSI (0.7-3.5 Bar) @ 3000 RPM	
20 Amp Alternator - Stator Output - AC Voltage	30 VAC @ 3600 RPM	
20 Amp Alternator - Regulator Output - DC Amps	1-20 Amps @3600 RPM	
20 Amp Alternator - Regulator Output - DC Volts	13-9-14.5 VDC @ 3600 RPM	
20/50 Amp Alternator - Stator Output - AC Voltage	45-50 VAC @ 3600 RPM	
20/50 Amp Alternator - Regulator Output - DC Amps	3-50 Amps @ 3600 RPM	
20/50 Amp Alternator - Regulator Output - DC Volts	13.9-14.5 VDC @ 3600 RPM If equipped with "battery-less charging system: 12.9-13.9 VDC @ 3600 RPM	
Starter Motor Current Draw Under Load	<190 Amps	

Engine Fluid and Sealant Specifications

FLUIDS AND SEALANTS	MODEL 540000	MODEL 610000
Engine Oil - Standard to Hot Temperature Operating Condition	Vanguard Synthetic 15W-50	
Engine Oil - Acceptable Alternate Service Specification	Synthetic 5W-30 - Service Class SF, SG, SH, SJ	
Crankcase Cover Silicone Sealant	Briggs & Stratton Liquid Sealant or Equivalent TB 1217F Silicone Sealant	
Starter Motor Solenoid Piston	TOTAL Multis EP2 or Equivalent Lithium-based Multipurpose Grease	
Carburetor - Throttle and Choke Plate Screw Threadlocker	LOCTITE 222 or Equivalent	
Throttle Position Sensor (TPS) - Adjustment Screw Threadlocker	LOCTITE 271 or Equivalent	
Ignition Armature and Crankshaft Position Sensor Screw Threadlocker	LOCTITE 242 or Equivalent	
Oil Pressure Switch Thread Tape	Teflon Sealing Tape	
Exhaust Manifold Fasteners or Stud Anti-Seize	Silver Anti-Seize Compound	
Valve Lapping Compound	LOCTITE Clover Silicone-Carbide 280-Grit or Equivalent	
Carburetor and Throttle Body Cleaner	General Purpose Carburetor Cleaner	

Torque Specifications

FASTENER	TORQUE
Air Block Plate to Crankcase Screw	18 lb-in (2 Nm)
Air Guide to Intake Manifold Screw	90 lb-in (10.2 Nm)
Air Guide to Back Plate Screw	90 lb-in (10.2 Nm)
Air Guide to Crankcase Screw	195 lb-in (22 Nm)
Alternator/Stator Mounting Screws	30 lb-in (3.4 Nm)
Alternator Wire Clamp to Cylinder	90 lb-in (10.2 Nm)
Back Plate to Cylinder	90 lb-in (10.2 Nm)
Blower Housing Post to Cylinder	110 lb-in (12.4 Nm)
Choke Knob to Key Switch Cover Nut	33 lb-in (3.7 Nm)
Coupling Nut to Blower Housing Post	90 lb-in (10.2 Nm)
Cyclonic Air Cleaner Strap to Bracket	90 lb-in (10.2 Nm)
Cyclonic Air Cleaner Bracket Assembly to Bracket	138 lb-in (15.6 Nm)
Cyclonic Air Cleaner Elbow to Throttle Body	90 lb-in (10.2 Nm)
Cyclonic Air Cleaner Studs to Intake Manifold	90 lb-in (10.2 Nm)
Cyclonic Bracket to Inlet Elbow	90 lb-in (10.2 Nm)
Cyclonic Bracket to Stud Nut	90 lb-in (10.2 Nm)
Cyclonic Intake Hose Clamp	18 lb-in (2 Nm)
Cyclonic Front Cover	90 lb-in (10.2 Nm)
Low Profile Air Cleaner Back Plate To Throttle Body Screw	90 lb-in (10.2 Nm)
Low Profile Air Cleaner Back Plate To ECM/Fuel Pump Module Bracket Screw	115 lb-in (13 Nm)
Cylinder Head Bolt - FOLLOW STEP TORQUE PROCEDURE	S1 - 116 lb-in (13.1 Nm) S2 - 232 lb-in (26.2 Nm) S3 - 348 lb-in (39.3 Nm)
Easy Access Cover to Blower Housing	30 lb-in (3.4 Nm)
Crankcase Cover Screw - FOLLOW STEP TORQUE PROCEDURE	S1 - 65 lb-in (7.3 Nm) S2 - 130 lb-in (14.7 Nm) S3 - 195 lb-in (22 Nm)
CKP Sensor Screw	23 lb-in (2.6 Nm)
EHT Sensor Screw	43 lb-in (4.9 Nm)
Fan to Flywheel	90 lb-in (10.2 Nm)
Flywheel Nut	121 lb-ft or 1450 lb-in (163.8 Nm)
Fuel Module to Module Bracket Screw	90 lb-in (10.2 Nm)
Fuel Pump to Blower Housing	40 lb-in (4.5 Nm)
Fuel Rail Clamps to Intake Manifold	90 lb-in (10.2 Nm)
Fuel Rail to Intake Manifold Screw	110 lb-in (12.4 Nm)
Fuse Block Stud/Plate Mount Screw	12 lb-in (1.4 Nm)
Fuse Block Bracket Mount Screw	90 lb-in (10.2 Nm)
Ignition Coil to Intake Manifold Screw	30 lb-in (3.4 Nm)
Intake Elbow Cover - Cover to Air Cleaner Bracket Screws	90 lb-in (10.2 Nm)

FASTENER	TORQUE
Intake Elbow Cover - Cover to Fuel Module Bracket Screws	90 lb-in (10.2 Nm)
Intake Manifold Stud Nut	135 lb-in (15.3 Nm)
Intake Manifold Stud	45 lb-in (5 Nm)
Key Switch Cover Screws	30 lb-in (3.4 Nm)
Lifting Bracket Screw	195 lb-in (22 Nm)
Module Bracket to Module Support	90 lb-in (10.2 Nm)
Module Support and Air Guide to Cylinder Head	90 lb-in (10.2 Nm)
Muffler Manifold To Cylinder Head Screw	195 lb-in (22 Nm)
Muffler Bracket to Crankcase Screw	195 lb-in (22 Nm)
Muffler Shield to Muffler Screw	87 lb-in (9.8 Nm)
Muffler Support Bracket Nut to Crankcase Cover Stud (Optional)	195 lb-in (22 Nm)
Muffler Support Bracket to Muffler Bracket Screw/Nut	195 lb-in (22 Nm)
Oil Cooler to Back Plate Screw	90 lb-in (10.2 Nm)
Oil Cooler to Blower Housing Screw	40 lb-in (4.5 Nm)
Oil Cooler Diverter Adapter	240 lb-in (27.1 Nm)
Oil Drain Plug - Metric	240 lb-in (27.1 Nm)
Oil Drain Plug - NPTF	128 lb-in (14.5 Nm)
Oil Drain Plug - Oil Guard Equipped Engine, Crankcase Cover Oil Drain Plug - NPTF	125 lb-in (14.1 Nm)
Oil Filter - Spin-on	100 lb-in (11.3 Nm)
Oil Guard Oil Bypass Cover	165 lb-in (18.6 Nm)
Oil Guard Oil Supply Pump Check Valve	375 lb-in (42.4 Nm)
Oil Guard Oil Supply Pump Hose Fitting	325 lb-in (36.7 Nm)
Oil Guard Oil Scavenge Pump Hose Fitting	215 lb-in (24.3 Nm)
Oil Guard Crankcase Ventilation Hose Fitting	215 lb-in (24.3 Nm)
Oil Guard Oil Supply/Scavenge Gerotor Pump Cover Screw	90 lb-in (10.2 Nm)
Oil Pressure Switch	15 lb-in (1.7 Nm) with Sealing Tape
Connecting Rod Screw	130 lb-in (14.7 Nm)
Regulator Assembly to Air Guide	90 lb-in (10.2 Nm)
Rocker Arm Adjuster Lock Nut	105 lb-in (11.9 Nm)
Rocker Arm Fulcrum Screw	105 lb-in (11.9 N-m)
Rotating Screen Stud to Flywheel	110 lb-in (12.4 Nm)
Debris Screen to Rotating Stud Screw	90 lb-in (10.2 Nm)
Spark Plug	170 lb-in (19.2 Nm)
Starter Motor to Engine Mounting Bolt	140 lb-in (15.8 Nm)
Starter Motor Support Bracket Mounting Bolt - To Starter Motor	50 lb-in (5.6 Nm)
Starter Motor Support Bracket Mounting Nut - To Engine Case	195 lb-in (22 Nm)
Starter Solenoid Post Nut	45 lb-in (5 Nm)
Solenoid to Starter Motor Mounting Nuts	71 lb-in (8 Nm)

FASTENER	TORQUE
Starter Solenoid Rotor Brush Strap Nut	87 lb-in (9.8 Nm)
Stud/Plate to Fuse Block Bracket	12 lb-in (1.4 Nm)
Throttle Body Collar Studs	95 lb-in (10.7 Nm)
Throttle Control to Mounting Bracket Screws	35 lb-in (4 Nm)
Throttle Cable Clamp to Speed Control Bracket Screw	23 lb-in (2.6 Nm)
Throttle Lever - Rotary Style - to Throttle Shaft Bolt	90 lb-in (10.2 Nm)
Valley Air Block Plate to Crankcase	18 lb-in (2 Nm)
Valve Cover Bolt	70 lb-in (7.9 Nm)
Valve Cover Breather Screw - Small 2 Bolt Design	43 lb-in (4.8 Nm)

FASTENER	TORQUE
Valve Cover Breather Screw - Large 4 Bolt Design	87 lb-in (9.8 Nm)
Wire Guard to Coupling Nut	90 lb-in (10.2 Nm)
Wire Harness Clip to Lift Bracket Screw	33 lb-in (3.7 Nm)
Wire Harness Ground to Crankcase	18 lb-in (2 Nm)
Wire Harness/ Fuel Hose Clamp	90 lb-in (10.2 Nm)
Wire Harness Ground to Throttle	18 lb-in (2 Nm)
Wire Harness Clamp to Intake Manifold Screw	90 lb-in (10.2 Nm)

Standard and Reject Sizes

ITEM	STANDARD SIZE	REJECT SIZE
CRANKCASE/CYLINDER		
Camshaft Bearing Bore Diameter	0.787-0.788 in (20.0-20.015 mm)	0.799 in (20.30 mm) or more
Cylinder Bore Circularity (Out-Of-Round)	0.0003 in (0.007 mm) - Measured in 5 spots at the top, middle and bottom of the cylinder bore	
Cylinder Bore Diameter - M61 and M54	3.366-3.367 in (85.5-85.525 mm)	3.370 in (85.598 mm) or more
CYLINDER HEAD		
Intake		
Valve Seat Angle - 3-Angle Seat	31°, 46°, 60°	
Valve Stem Diameter	0.234-0.235 in (5.945-5.960 mm)	0.228 in (5.791 mm) or less
Valve Guide Bore Diameter	0.236-0.237 in (6.006-6.026 mm)	0.240 in (6.106 mm) or more
Exhaust		
Valve Seat Angle - 3-Angle Seat	31°, 46°, 60°	
Valve Stem Diameter	0.233-0.234 in (5.940-5.955 mm)	0.228 in (5.791 mm) or less
Valve Guide Bore Diameter	0.236-0.237 in (6.006-6.026 mm)	0.240 in (6.106 mm) or more
CRANKCASE COVER		
Camshaft Bearing Bore Diameter	0.787-0.788 in (20.0-20.025 mm)	0.799 in (20.30 mm) or more
CRANKSHAFT		
Crank Pin Journal Diameter	1.693-1.694 in (43.0-43.02 mm)	1.691 in (42.95 mm) or less
MAG Bearing Journal Diameter	1.771-1.772 in (44.976-45.0 mm)	1.769 in (44.926 mm) or less
PTO Bearing Journal Diameter	1.771-1.772 in (44.976-45.0 mm)	1.769 in (44.926 mm) or less
CAMSHAFT		
MAG Bearing Journal Diameter	0.785-0.786 in (19.947-19.960 mm)	0.783 in (19.897 mm) or less
PTO Bearing Journal Diameter	0.785-0.786 in (19.947-19.960 mm)	0.783 in (19.897 mm) or less
CONNECTING ROD		
Crank Pin Bearing Bore Diameter	1.695-1.696 in (43.06-43.08 mm)	1.698 in (43.13 mm) or more
Piston Pin Bearing Bore Diameter	0.827-0.828 in (21.014-21.021 mm)	0.830 in (21.071 mm) or more
PISTON		
Piston Pin Diameter	0.826-0.827 in (21.0-21.004 mm)	0.826 in (20.970 mm) or less
Piston Pin Bore Diameter	0.827-0.827 in (21.006-21.013 mm)	0.829 in (21.063 mm) or more
Top Compression Ring End Gap	0.008-0.014 in (0.20-0.35 mm)	0.044 in (1.11 mm) or more
Middle Oil Wiper Ring End Gap	0.014-0.022 in (0.35-0.55 mm)	0.052 in (1.31 mm) or more
Bottom Oil Control Ring End Gap	0.008-0.028 in (0.2-0.70 mm)	0.063 in (1.59 mm) or more
Top Compression Ring Side Clearance	0.004-0.005 in (0.09-0.13 mm)	0.012 in (0.31 mm) or more



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