

Pagination Page

⚠ DANGER

- See General Warnings on page 1-2.

⚠ WARNING

- See General Warnings on page 1-2.

GENERAL INFORMATION

The vehicles addressed in this manual are equipped with heavy-duty transaxles. The transaxle utilizes internal gearing to change vehicle direction. Because the transaxle is used to reverse vehicle direction, the engine, drive clutch, belt, and driven clutch rotate in the same direction; therefore, the engine and clutches are not subjected to reversing loads. This reduces maintenance requirements on the engine and clutches. With the transaxle, power is transferred from the engine through the drive clutch, the drive belt, the driven clutch, and then through the transaxle to the wheels.

TRANSAXLE IDENTIFICATION

The transaxle serial number is located on a bar code decal installed on the axle tube (Example: ED65XX00FO1234567890). The ninth and tenth digits identify the type of transaxle.

- FO - Open Differential
- FD - Limited Slip Differential

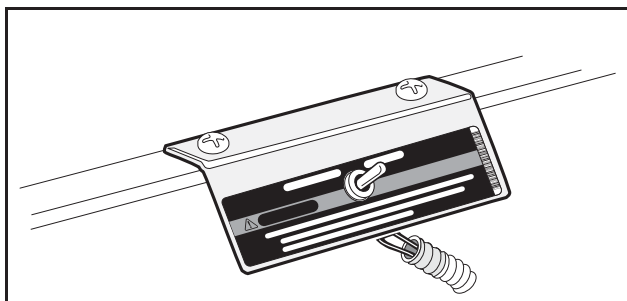
SHIFTER LEVER

A shifter lever, connected to a shifter arm, is used to change the gears to one of three shift positions: forward (F), neutral (N), or reverse (R). Bring the vehicle to a complete stop before changing F or R direction.

MAINTENANCE/OPERATE SWITCH

⚠ WARNING

- With the switch in the **MAINTENANCE** position and the engine running, the vehicle may move suddenly if the Forward/Neutral/Reverse handle is shifted or accidentally bumped. To prevent this, chock the front and rear wheels and firmly set the park brake before servicing or leaving the vehicle.



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Figure 18-1 MAINTENANCE/OPERATE Switch

The maintenance/operate switch is used by a trained technician to do certain maintenance functions with the engine on.

NOTE: Make sure that the Maintenance/Operate switch is set to *OPERATE* after the vehicle is serviced.

| POSITION | DESCRIPTION |
|-------------|---|
| OPERATE | Normal Operation The engine will not operate in neutral. |
| MAINTENANCE | The engine will operate in neutral (N). The vehicle will not operate in the forward (F) or reverse (R) position. |

GOVERNOR SYSTEM

The governor system regulates vehicle ground speed. It is mounted inside the transaxle and is driven by transaxle gears. If any of the governor linkages are removed in order to service other components, readjustment of the governor linkage is required. **See Governor Cable Installation and Adjustment on page 22-3.**

TRANSAXLE SERVICE

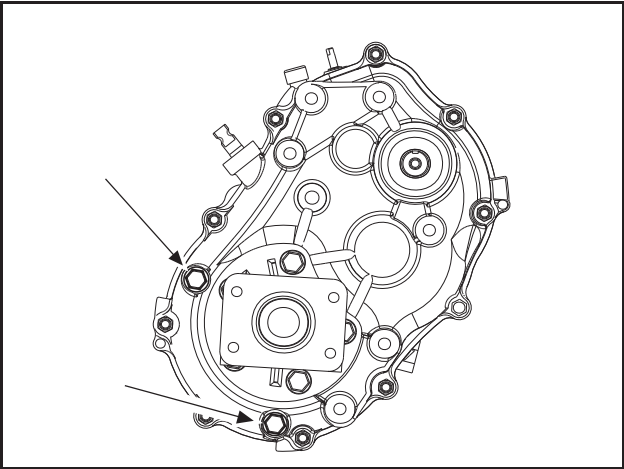
The transaxle is extremely durable and should require very little service under normal operating conditions. The only service required is to maintain proper lubricant level. **See Lubrication on page 18-2.** Under normal operating conditions, adjustment to the system should not be required.

LUBRICATION

There are two oil port plugs located on the right (driven clutch) side of the transaxle (**Figure 18-2, Page 18-3**). When the vehicle is on a level surface, use the upper plug as a lubricant level indicator. Lubricant level should be even with the bottom of level indicator hole. Use the lower plug for draining.

Oil Change – Transaxle

1. When draining transaxle oil, remove both plugs to allow the oil to drain faster.
2. Clean and reinstall the drain plug and gasket before filling the transaxle with new lubricant. Tighten drain plug to 17 lb·ft (23 N·m).
3. Use a funnel when filling the transaxle through the lubricant level indicator hole. Fill with 67.6 fl-oz (2 L) 80-90 WT. API class GL or 80-90 WT. AGMA class 5 EP gear lubricant (or until lubricant begins to run out of the level indicator hole).
4. Install upper plug and gasket and tighten to 17 lb·ft (23 N·m).



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Figure 18-2 Lubricant Level Plug and Drain Plug

TOOLS REQUIRED FOR THIS SECTION

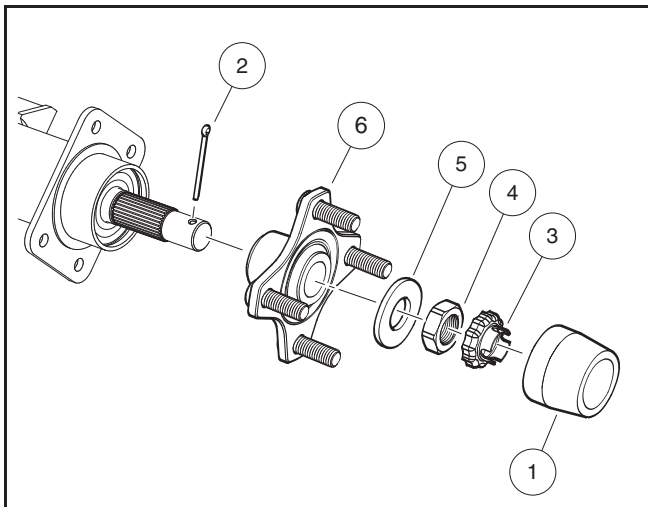
| | | |
|---|--------------------------------|------------------------------------|
| Hydraulic floor jack (or chain hoist) | Torque wrench, 3/8-in. drive | 1/2-in. combination wrench |
| Jack stands (2) (one ton capacity) | 3/8-in. socket, 3/8-in. drive | 9/16-in. combination wrench |
| Standard slip joint pliers | 7/16-in. socket, 3/8-in. drive | Small flat blade screwdriver |
| External snap ring pliers (.0047- in. tip) | 1/2-in. socket, 3/8-in. drive | Medium flat blade screwdrivers (2) |
| 90° Internal snap ring pliers (0.090-in. tip) | 9/16-in. socket, 3/8-in. drive | No. 2 phillips-head screwdriver |
| 16-in. rolling head prybar | 5/8-in. socket, 3/8- in. drive | 1/4-in. nut driver |
| Plastic or rubber mallet | Axle seal tool | 5/16-in. nut driver |
| Ratchet wrench, 3/8-in. drive | 7/16-in. combination wrench | |

REAR HUBS

REAR HUB REMOVAL

1. Turn the key switch to the OFF position and remove the key, and place the Forward/Neutral/Reverse handle in the NEUTRAL position.
2. Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. Place chocks at the front wheels and loosen lug nuts on both rear wheels.
4. Remove the rubber dust cap (1).
5. Remove and discard the cotter pin (2) (**Figure 18-3, Page 18-4**).
6. Remove nut locking cap (3) and loosen the hub nut (4) on the axle shaft.
7. Lift and support the rear of vehicle.
8. Remove the lug nuts and wheel.
9. Slide brake drum off hub.
10. Remove hub nut (4) and large flat washer (5) and pull hub (6) off axle shaft. **See following NOTE.**

NOTE: If the hub (6) does not slide easily off the axle shaft, use a two or four-jaw wheel puller to remove the hub.



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Figure 18-3 Rear Hub Exploded View

REAR HUB INSTALLATION

1. Inspect brake shoes for wear and replace if necessary. **See Wheel Brake Assemblies section.**

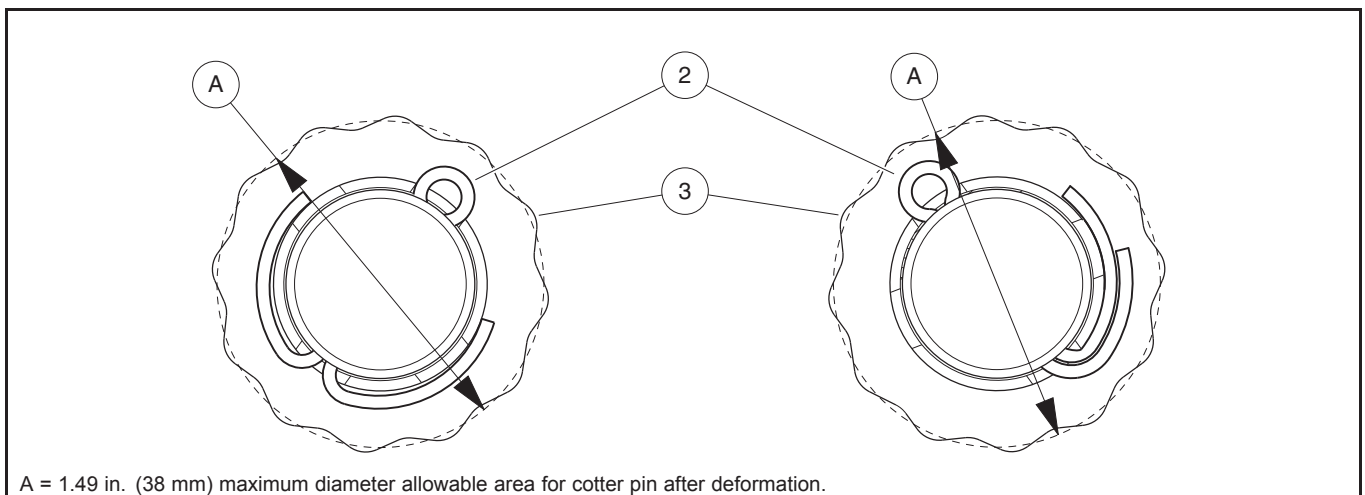
NOTE: If brake shoes are replaced on one side, replace the opposite side also.

2. Clean the splines and threaded portion of the axle shaft.
3. Apply anti-seize compound to both the axle shaft splines and hub (6) splines. **See following CAUTION.**

CAUTION

- Do not allow anti-seize compound to contact the brake drum or shoes.

- Slide hub (6) onto axle shaft (**Figure 18-3, Page 18-4**).
- Install the large flat washer (5) onto the threaded portion of the axle.
- Install hub nut (4) and advance the nut to the large flat washer.
- Install brake drum onto hub.
- Install the tire and wheel and finger-tighten the lug nuts.
- Lower the rear of the vehicle.
- Tighten the hub nut (4) to 147 lb·ft (200 N·m) initially. If possible, position the locking cap (3) on hub nut (4) and install new cotter pin (2). If necessary, tighten hub nut (4) further (177 lb·ft (240 N·m) max.) until the locking cap (3) and new cotter pin (2) can be installed.
- Deform cotter pin (2) as shown (**Figure 18-4, Page 18-5**). Either way is acceptable. No part of the cotter pin (2) should protrude beyond the perimeter of the locking cap (3).
- Install rubber dust cap (1).
- Tighten lug nuts to 65 lb·ft (88 N·m) using a crisscross pattern.
- Connect battery and spark plug wire.
See Connect the Battery - Gasoline Vehicles on page 1-4.



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Figure 18-4 Cotter Pin Deformation

AXLE TUBES, AXLE SHAFTS, DIFFERENTIAL GUARD, AND WHEEL BEARINGS

Removal of the transaxle is not required for servicing or replacing axle shafts, axle bearings, or axle shaft oil seals. If the transaxle is to be removed from the vehicle, do not remove the wheels, axle shafts, or axle tubes first. Instructions for removing the transaxle from the vehicle begin on page 18-10.

NOTE: The axle shaft oil seals (7) are located in the transaxle gearcase (4), not the axle tubes (2) (Figure 18-7, Page 18-8). The axle tubes must be removed in order to replace these oil seals.

DIFFERENTIAL GUARD REMOVAL

Differential guard is installed on some vehicles to protect the transaxle, remove it before working on the axle tube.

1. Clean debris from the differential guard and mounting bolts.
2. Remove the four bolts (1) securing the differential guard (2) to the transaxle (3) (Figure 18-5, Page 18-6).
3. Remove the differential guard from the transaxle.

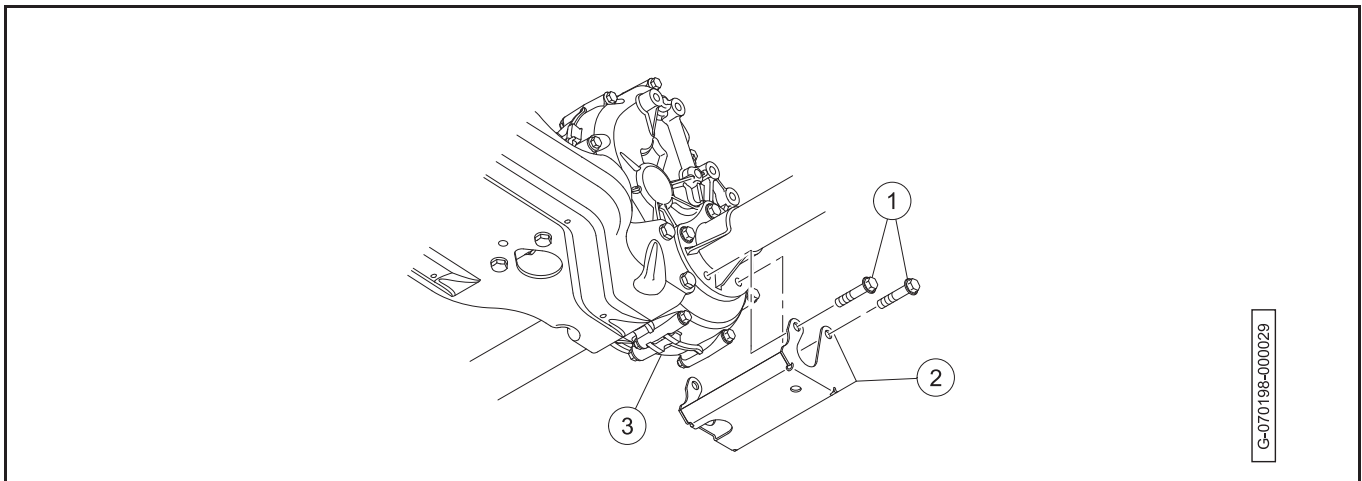


Figure 18-5 Differential Guard Removal

DIFFERENTIAL GUARD INSTALLATION

1. Clean the threads of the four axle tube mounting holes for the differential guard.
2. Secure the differential guard (2) to the transaxle (3) with the 4 bolts (1). Tighten the four bolts from 25 ft·lb to 31 ft·lb (34.3 N·m to 42.2 N·m) (Figure 18-6, Page 18-7).

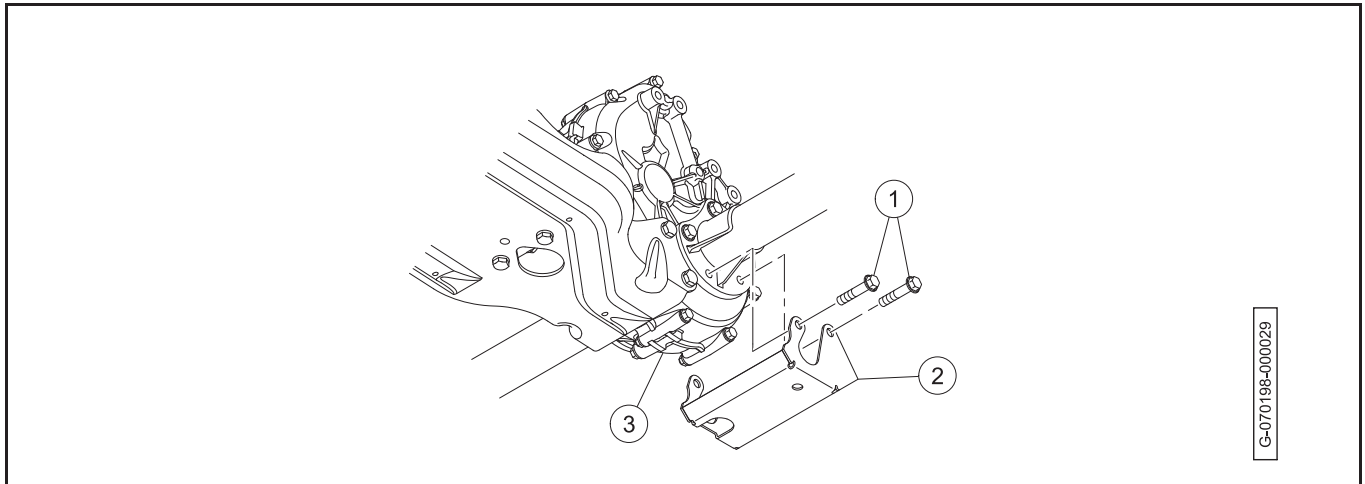


Figure 18-6 Differential Guard Installation

AXLE TUBE AND AXLE SHAFT REMOVAL

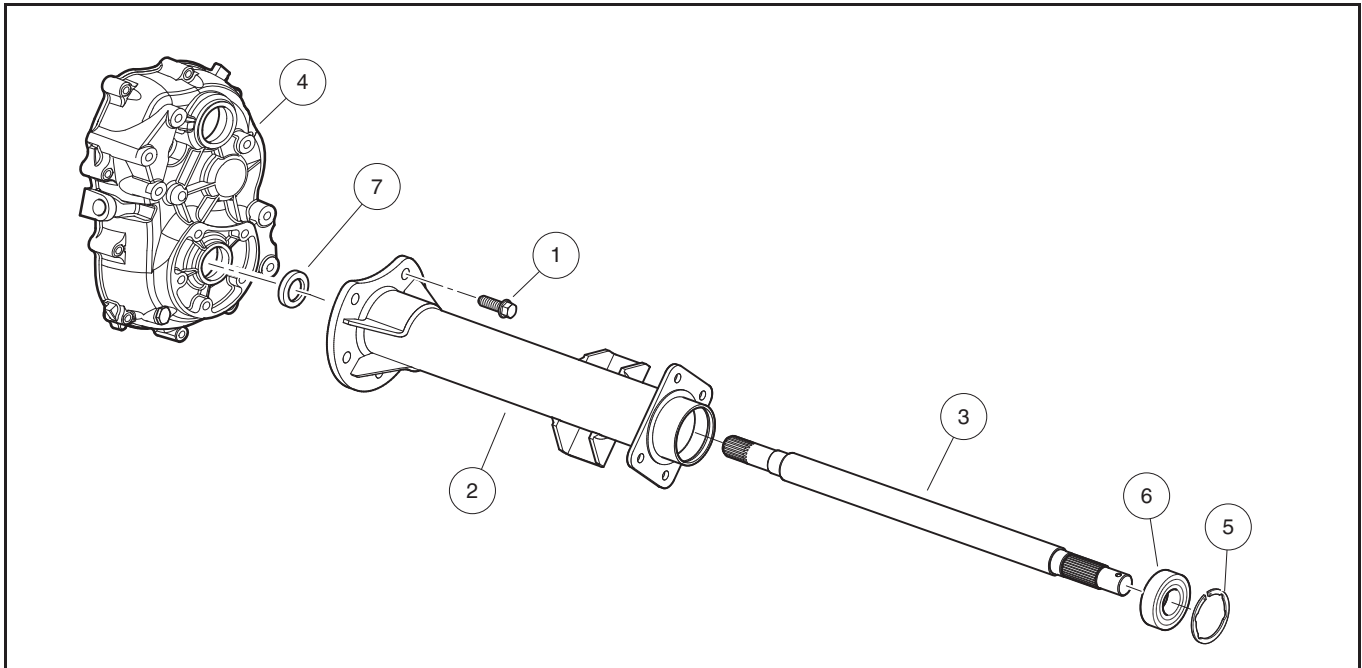
See General Warnings, Section 1, Page 1-2.

The transaxle has two axle shafts. If only a tube or shaft is to be serviced, it can be done one side at a time without removing the transaxle.

1. Clean debris from drain plug and area around it at the bottom of the transaxle. Drain oil. Install plug after draining.
2. If removing entire transaxle from vehicle, remove the transaxle and clean it in preparation for disassembly. **See Transaxle Removal on page 18-10. See following NOTE.**

NOTE: After cleaning, move transaxle to a clean location before disassembly.

3. If removing only one axle tube or shaft from vehicle, clean that tube and hub in preparation for disassembly.
4. Remove hub. **See Rear Hub Removal on page 18-4.**
5. Remove the five flange-head bolts (1) securing axle tube (2) to transaxle (**Figure 18-7, Page 18-8**).
6. Avoiding damage caused by dragging splines across lip of oil seal (7) in transaxle gearcase, carefully pull axle tube (2) and shaft (3) from transaxle.



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Figure 18-7 Axle Tube, Shaft, Bearing and Oil Seal

AXLE TUBE AND AXLE SHAFT INSTALLATION

1. Clean mating surfaces of axle tube (2) flange and transaxle gearcase (4). Also clean the threads of the five axle tube mounting holes in the gearcase. **See following CAUTION.**

CAUTION

- If necessary, clean each mounting hole with a thread tap (M10 x 1.25 pitch) before installing flange bolts.
2. Clean and lubricate the oil seal (7) in the transaxle gearcase (4) with oil (**Figure 18-7, Page 18-8**).
 3. Clean inner end of axle shaft (3). Avoiding damage caused by dragging splines across lip of oil seal (7) in transaxle gearcase (4), carefully install axle shaft (3) and tube (2). **See following NOTE.**

NOTE: It may be necessary to rotate each shaft (3) slightly to engage the splines in the differential.

4. Secure axle tube (2) to gearcase (4) with flange bolts (1). Use a crisscross pattern to tighten flange bolts to 28 lb·ft (38 N·m).
5. Install hub. **See Rear Hub Installation on page 18-4.**
6. If entire transaxle was removed from vehicle, install transaxle. **See Transaxle Installation on page 18-13.**
7. Refill transaxle with appropriate type and volume of oil. **See Oil Change – Transaxle on page 18-2.**

REAR WHEEL BEARING REMOVAL

1. Remove hub. **See Rear Hub Removal on page 18-4.**
2. Remove axle tube (2) from transaxle. **See Axle Tube and Axle Shaft Removal on page 18-7.**
3. Remove the snap ring (5) that is in front of the bearing (6) and discard (**Figure 18-7, Page 18-8**).

4. Drive axle shaft (3) and bearing (6) from outer end of axle tube (2) as an assembly.
5. Use a puller to remove bearing (6) from axle shaft (3). **See following CAUTION.**

CAUTION

- To prevent damaging the threads on end of axle shaft (3), install hub nut to cover initial threads prior to using puller.

REAR WHEEL BEARING INSTALLATION

1. Press new bearing (6) onto axle shaft (3) until fully seated.
2. Clean inside axle tube (2) where new bearing (6) will sit and lightly lubricate the bore (**Figure 18-7, Page 18-8**).
3. Using an appropriate sized bearing driver that fits the outer race, drive in bearing/shaft assembly (3 and 6) until fully seated in tube (2).
4. Install new snap ring (5).
5. Install axle tube (2). **See Axle Tube and Axle Shaft Installation on page 18-8.**
6. Install hub. **See Rear Hub Installation on page 18-4.**

AXLE SHAFT OIL SEAL REMOVAL

The rear axle tubes (2) must be unbolted from the transaxle to replace oil seals (7) (**Figure 18-7, Page 18-8**).

1. Clean debris from drain plug and area around it at the bottom of the transaxle. Drain oil. Install plug after draining.
2. Remove axle tube (2) from gearcase (4) (**Figure 18-7, Page 18-8**). **See Axle Tube and Axle Shaft Removal on page 18-7.**
3. Pull oil seal (7) from gearcase (4).

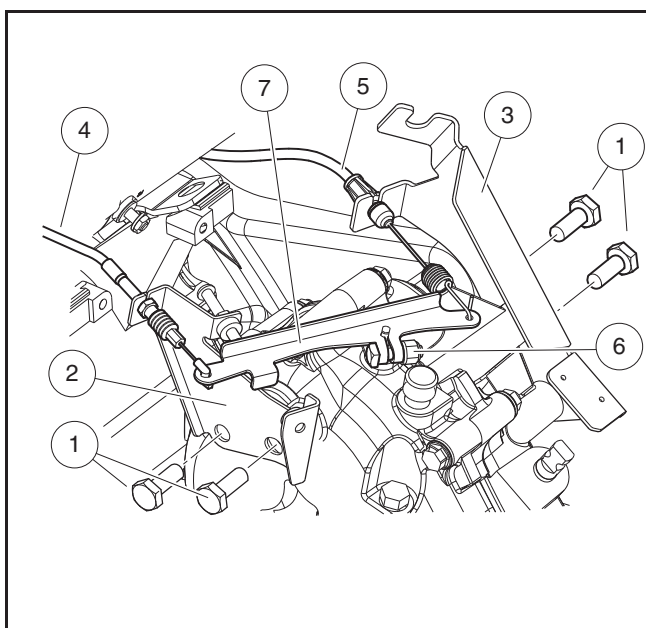
AXLE SHAFT OIL SEAL INSTALLATION

1. Clean bore in gearcase (4) where new oil seal (7) will sit (**Figure 18-7, Page 18-8**).
2. Using an appropriate sized seal driver, drive in new oil seal (7) until 0.0393 in. (1 mm) below surface, not fully seated.
3. Clean end of axle shaft (3) and carefully install axle tube (2) to avoid damaging new oil seal (7) with splines of axle shaft. **See Axle Tube and Axle Shaft Installation on page 18-8.**
4. Refill transaxle with appropriate type and volume of oil. **See Oil Change – Transaxle on page 18-2.**

TRANSAXLE REMOVAL

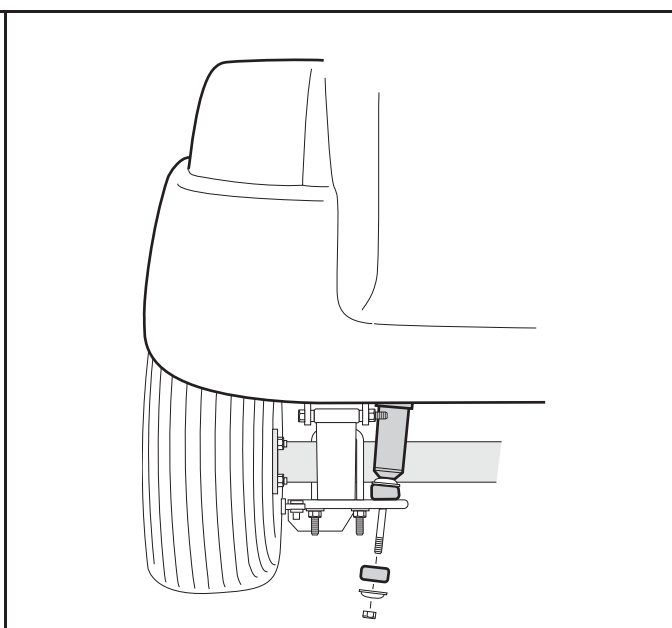
See General Warnings on page 1-2.

1. Turn the key switch to the OFF position and remove the key, and place the Forward/Neutral/Reverse handle in the NEUTRAL position.
2. Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. Place chocks at the front wheels and loosen lug nuts on both rear wheels.
4. Disconnect air intake hose, vent hose, and fuel line from throttle body and accelerator cable from electrical component box. **See Kohler ECH440 - Fuel System, Section 22, Page 22-1.**
5. Disconnect gray 18-pin connector from ECU.
6. Disconnect engine ground cable lead from main wire harness.
7. Disconnect 3-wire plug from limit switch on transaxle.
8. Disconnect three wires of main wire harness from starter/generator (**Figure 27-14, Page 27-13**).
9. Loosen jam nuts (1) securing shifter cable (2) to FNR/accelerator cable mounting bracket. Then, remove bowtie clip (3) to disconnect shifter cable end (4) from transaxle shift lever (5) and set shifter cable (2) aside (**Figure 18-18, Page 18-15**).
10. Remove bolts (1) securing governor cable bracket (2) and FNR/accelerator cable bracket (3) to transaxle (**Figure 18-8, Page 18-10**). Do not disconnect cables (4 and 5).
11. Unhook governor cable (4) and accelerator cable (5) from the governor arm (7).



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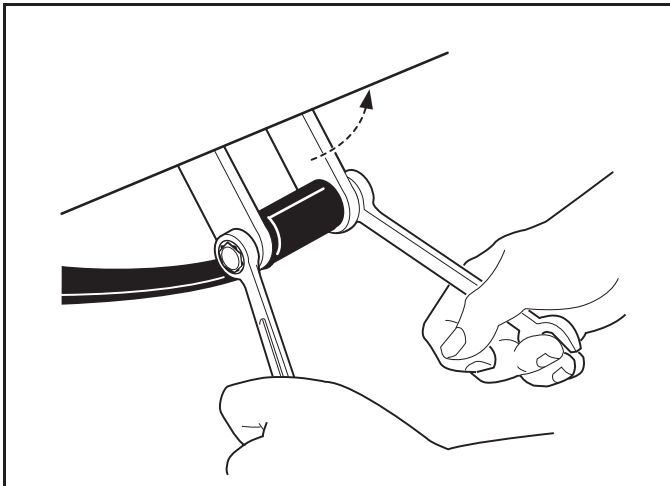
Figure 18-8 Governor Arm, Cable and Brackets



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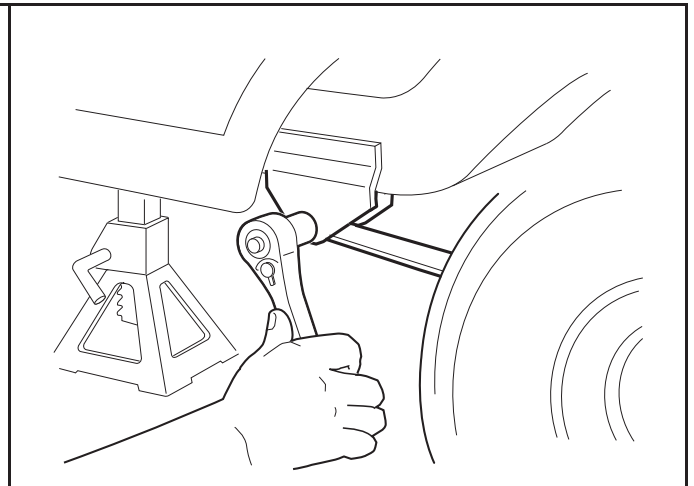
Figure 18-9 Disconnect Shock Absorbers

12. Disconnect brake cables from brake assemblies. **See Wheel Brake Assemblies section.**
13. Remove the panhard. **See Panhard and Bracket Removal on page 9-4.**
14. Remove lower shock mounting hardware from both rear shocks (**Figure 18-9, Page 18-10**).



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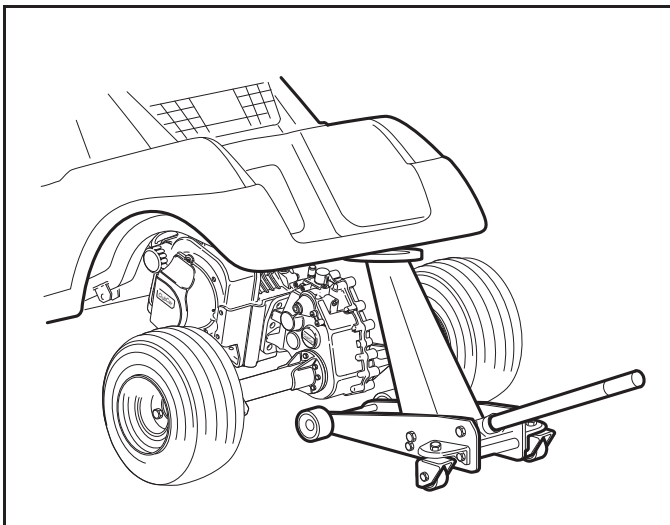
Figure 18-10 Disconnect Rear Shackles



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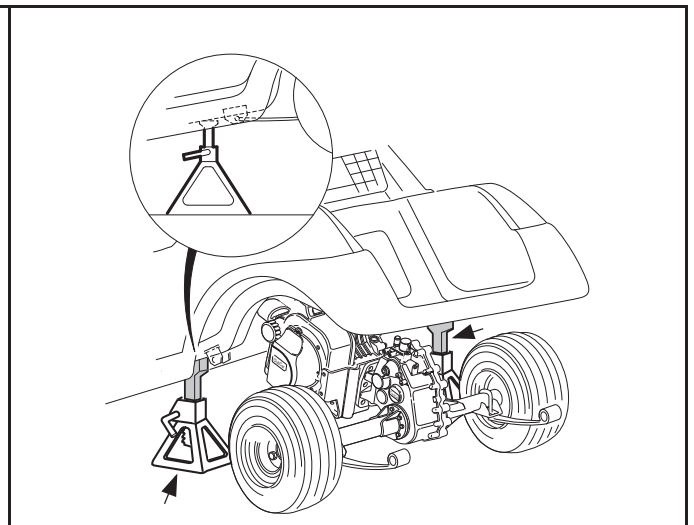
Figure 18-11 Disconnect Front of Leaf Spring

15. Position floor jack under rear crossmember of chassis or trailer hitch mount (if equipped) (**Figure 18-12, Page 18-11**). See **WARNING "Lift only one end of the vehicle..."** in **General Warnings** on page 1-2.
16. Raise vehicle just enough to relieve weight on leaf springs, then remove bolts securing leaf springs to shackles (**Figure 18-10, Page 18-11**).
17. Remove bolts securing front of leaf springs (**Figure 18-11, Page 18-11**).



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Figure 18-12 Raise Vehicle



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Figure 18-13 Position Jack Stands On Both Sides of Frame

18. Continue raising vehicle until chassis is higher than the top of the transaxle (i.e. enough to allow powertrain to be rolled out from under vehicle) (**Figure 18-12, Page 18-11**). Position jack stands, adjusted to support the vehicle at this height, under the frame crossmember between the leaf spring mounts and side stringers, just forward of each rear wheel (**Figure 18-13, Page 18-11**). Lower the floor jack to allow the jack stands to support the vehicle.
19. Remove floor jack from beneath vehicle.
20. Grasp ends of leaf springs at rear of vehicle and carefully pull the powertrain until snubber at front of engine pan is free of the chassis. Gently lower front of powertrain to the floor. The powertrain should be completely disconnected from vehicle and resting on floor.

21. Roll powertrain out from under vehicle.
22. Place blocks under the engine pan so they will completely support the engine and keep it **level to the floor** (**Figure 18-14, Page 18-12**). **See following NOTE.**

NOTE: Place the blocks so they will support the engine when the transaxle is detached and moved away from the powertrain.

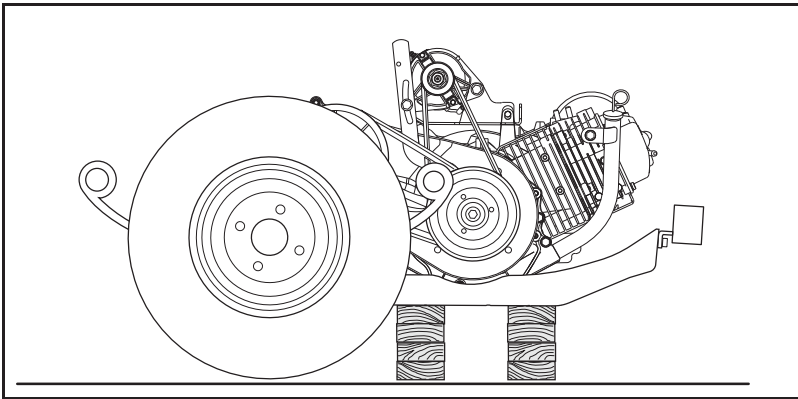
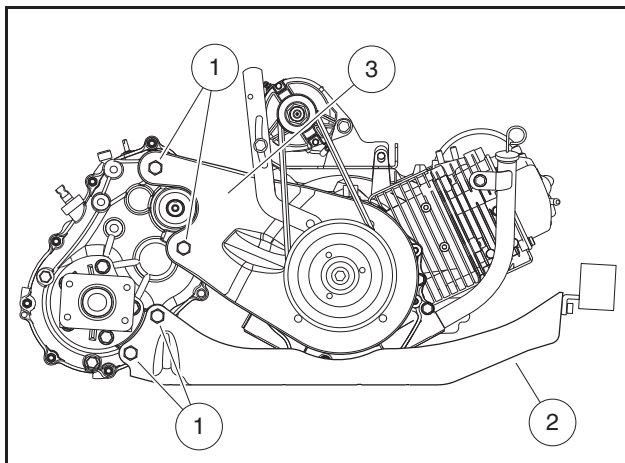


Figure 18-14 Remove Powertrain and Place Wood Blocks Under Engine Pan

23. Remove oil drain plug and drain all oil from transaxle. Dispose of gear oil properly.
24. Remove driven clutch. **See Driven Clutch Removal, Section 24, Page 24-13.**
25. Remove eight bolts (1) total that secure transaxle to powertrain (**Figure 18-15, Page 18-13**) at the following locations:
 - Four bolts (1) at engine pan (2).
 - Two bolts (1) at clutch plate (3).
 - Two bolts (1) at muffler bracket.
26. Roll transaxle from engine pan (2). **See following NOTE.**

NOTE: The transaxle weighs approximately 58 lb (26.2 kg).

27. If replacing transaxle, remove leaf springs, wheels, hubs and brake assemblies and retain for installation on new transaxle. **See Rear Suspension section. See Wheel Brake Assemblies section.**



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Figure 18-15 Transaxle Mounting Bolts

TRANSAXLE INSTALLATION

See General Warnings on page 1-2.

1. Installation is reverse of removal procedure. When attaching transaxle to powertrain, initially install the eight bolts (1) finger-tight (**Figure 18-15, Page 18-13**). Then, tighten fasteners in the following order:
 - 1.1. Tighten the two bolts (1) at clutch plate (3) to 50 lb·ft (68 N·m).
 - 1.2. Tighten the four bolts (1) at engine pan (2) to 50 lb·ft (68 N·m).
 - 1.3. Tighten the two bolts (1) at muffler bracket to 50 lb·ft (68 N·m).
 - 1.4. Tighten the governor cable bracket (2) and FNR/accelerator cable bracket (2) bolts to 50 lb·ft (68 N·m) (**Figure 18-8, Page 18-10**).
 - 1.5. Tighten leaf spring hardware to 19 lb·ft (26 N·m) at chassis and shackle. **See Rear Suspension section.**
 - 1.6. Tighten lower nuts of shock absorbers until cushions expand to be the same diameter as the mounting washers.
 - 1.7. Tighten transaxle drain plug to 17 lb·ft (23.5 N·m).
2. Fill transaxle with appropriate type and volume of oil. **See Oil Change – Transaxle on page 18-2.**
3. Ensure that all wires and cables are secured properly with wire ties. **See following WARNING.**

⚠ WARNING

- If wires and cables are removed or replaced make sure they are properly routed and secured to vehicle frame. Failure to properly route and secure wires and cables could result in vehicle malfunction, property damage or personal injury.
4. Connect battery and spark plug wire.
See Connect the Battery - Gasoline Vehicles on page 1-4.
 5. Check governor adjustment and correct if necessary. **See Governor Cable Installation and Adjustment, Section 22, Page 22-3.**
 6. Check engine RPM setting. Adjust if necessary. **See Engine RPM Adjustment, Section 22, Page 22-9.**

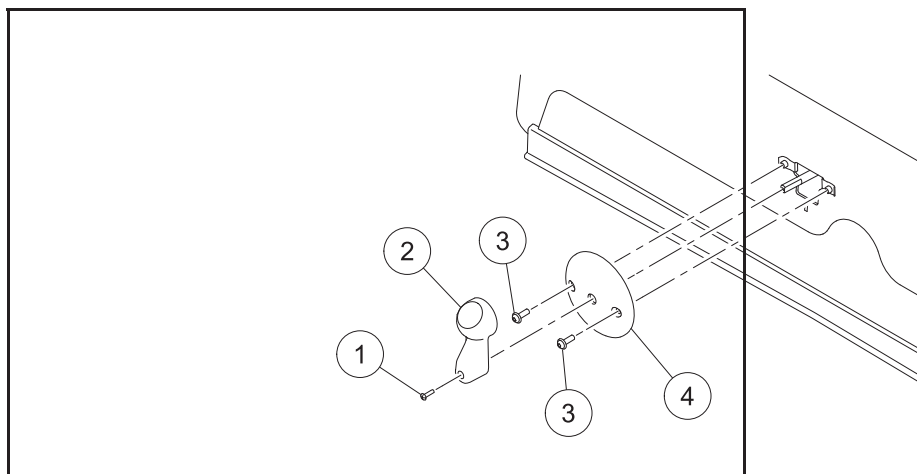
FORWARD/NEUTRAL/REVERSE HANDLE

FORWARD/NEUTRAL/REVERSE HANDLE REMOVAL

1. Remove the bolt (1) from the Forward/Neutral/Reverse handle (2) (**Figure 18-16, Page 18-14**).
2. Remove the bolts (3) from the bezel (4).
3. Remove the bezel.

FORWARD/NEUTRAL/REVERSE HANDLE INSTALLATION

1. Install the bezel (4) and the bolts (3). Tighten the bolts to 22 lb·in (2.5 N·m) (**Figure 18-16, Page 18-14**).
2. Install the Forward/Neutral/Reverse handle (2).
3. Install the bolt (1). Tighten the bolt to 15 lb·in (1.5 N·m).



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Figure 18-16 Forward/Neutral/Reverse Handle

SHIFTER CABLE

See General Warnings on page 1-2.

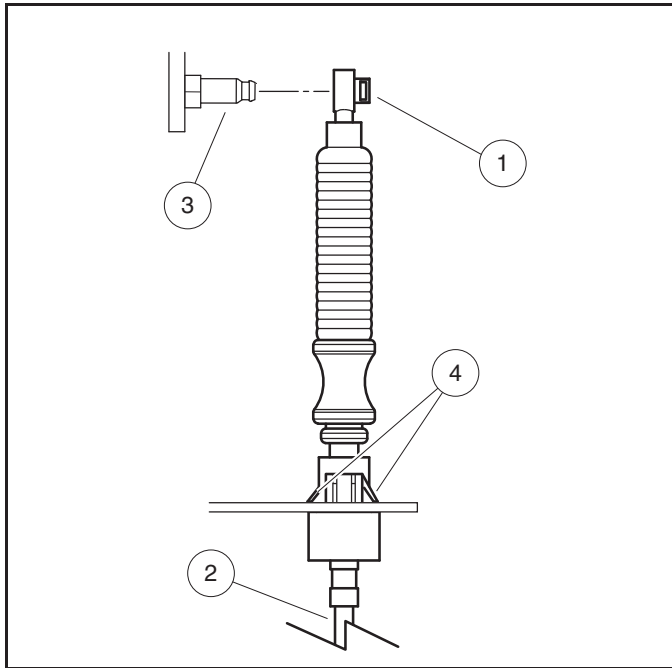
If the Forward/Neutral/Reverse shifter cable is damaged in any way, it must be replaced.

SHIFTER CABLE REMOVAL

NOTE: Before removing cable, note cable routing and positions of wire ties or other devices securing the cable to the vehicle. When installed, cable must be routed and secured as it was originally.

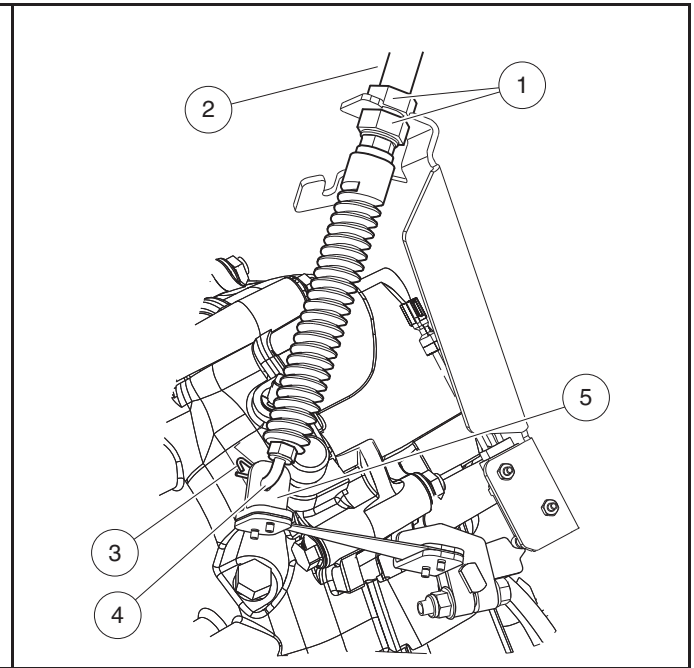
1. Turn the key switch to the OFF position and remove the key. Place the Forward/Neutral/Reverse handle in the NEUTRAL position and chock the wheels.
2. Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**

3. Push the cable end socket (1) off the stud (3) on the Forward/Neutral/Reverse shifter handle (**Figure 18-17, Page 18-15**).
4. Press in tangs (4) anchoring shifter cable (2) to chassis and push out of mounting hole.
5. Loosen jam nuts (1) securing shifter cable (2) to FNR/accelerator cable bracket (3) (**Figure 18-18, Page 18-15**). Then, remove bowtie clip (3) to disconnect shifter cable end (4) from transaxle shift lever (5).
6. Cut wire ties securing shifter cable to chassis.
7. Make note of cable routing, then remove shifter cable from vehicle.



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Figure 18-17 Shifter Cable at FNR Handle



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Figure 18-18 Shifter Cable at Transaxle

SHIFTER CABLE INSTALLATION

1. Install shifter cable (2), routing it exactly as it was originally, from Forward/Neutral/Reverse shifter handle to transaxle.
2. Place rear of cable (2) in FNR/accelerator cable bracket with a jam nut (1) on each side of bracket (**Figure 18-18, Page 18-15**). Tighten jam nuts (1) to 22 lb·ft (29.8 N·m).
3. Hook shifter cable end (4) into transaxle shift lever (5) and secure with bowtie clip (3).
4. Feed front of cable (2) through its mounting hole and push the plastic anchor into hole until tangs (4) snap into place (**Figure 18-17, Page 18-15**).
5. Snap cable end socket (1) onto stud (3) of Forward/Neutral/Reverse shifter handle.
6. Secure shifter cable along chassis with wire ties if required.
7. Connect battery and spark plug wire.
See Connect the Battery - Gasoline Vehicles on page 1-4.

SHIFTER CABLE ADJUSTMENT

Cable is properly adjusted when both the Forward/Neutral/Reverse handle and shift lever on transaxle are in the NEUTRAL position at the same time.

To adjust, the jam nuts (6) at the FNR/accelerator cable bracket must be loosened and moved forward or backward as required (**Figure 18-18, Page 18-15**). Tighten jam nuts (6) to 22 lb·ft (29.8 N·m).

⚠ DANGER

- See General Warnings on page 1-2.

⚠ WARNING

- See General Warnings on page 1-2.

GENERAL INFORMATION

⚠ WARNING

- To prevent damage to the ECU, never mix the black and gray connectors that attach to it. The black connector is tethered to the ECU mounting plate to help avoid installing it in the gray port.

This section contains the information required to correctly troubleshoot the EFI gas vehicle. In addition to troubleshooting, this section contains general information on the electrical system and the circuits of the electrical system.

ACCESSORIES

For certain powered accessories, use the 9-pin connector located behind the instrument panel.

FEATURES OF THE ELECTRONIC FUEL INJECTION (EFI) SYSTEM

- Closed-loop system, oxygen (O₂) sensor included
- Controls fuel pump, fuel injector, malfunction indicator light (MIL)
- Inputs: Temperature/Manifold Absolute Pressure (TMAP), Throttle Position Sensor (TPS), oxygen (O₂) sensor, crank sensor, ignition timing, cylinder head temp
- Separate EFI wire harness

GROUND LOCATIONS

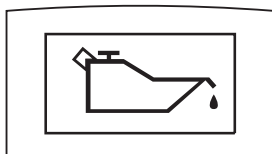
Electrical grounds are located at the following areas:

- **At the Battery:** The starter/generator, voltage regulator, ECU, throttle position sensor and fuel pump module all connect to the main wire harness and goes to the B– battery terminal.
- **Between Engine and Battery:** The engine and chassis each have a separate lead that connects to the main wire harness and goes to the B– battery terminal.
- **Top of Fuel Tank:** The fuel tank has a lead that connects to the main wire harness and goes to the B– battery terminal.

LOW OIL WARNING LIGHT

CAUTION

- Failure to add oil immediately when the low oil warning light stays on may result in permanent engine damage.

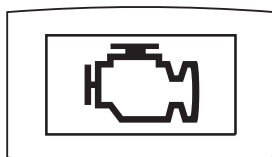


The low oil warning light gives a visual indication of an oil level problem.

Figure 19-1 Low Oil Warning Light

| STATUS | CONDITION |
|--------|--|
| OFF | Normal Operation |
| ON | <p>When possible:</p> <ol style="list-style-type: none"> 1. Stop the vehicle. 2. Turn the key to OFF. 3. Examine the engine oil level. 4. Add engine oil as necessary. 5. If the low oil level warning light stays on, have a trained technician examine the vehicle. |

MALFUNCTION INDICATOR LIGHT



The malfunction indicator light (MIL) gives a visual indication of an engine fault. When the key switch is set to ON, the MIL will turn on for 3 seconds.

If an engine fault is sensed, the MIL will stay on. **See the Kohler Engine Service Manual for more information.**

TROUBLESHOOTING GUIDE

The following troubleshooting guides will be helpful in identifying operating difficulties should they occur. The guides include the symptom, probable cause and suggested checks. The procedures used in making these checks can be found in the referenced sections of the maintenance and service manual.

GASOLINE POWERTRAIN

| TROUBLESHOOTING GUIDE | | |
|---|--|--|
| SYMPTOM | POSSIBLE CAUSES | CORRECTIVE ACTION |
| Starter fails to operate. | Maintenance/Operate switch is in the MAINTENANCE position | Set the Maintenance/Operate switch to OPERATE |
| | Fuse is blown | See the Fuses Test Procedure |
| | Battery is dead | See the Battery Test Procedure |
| | Starter control circuit is not operating | See the Key Switch (Start Circuit) Test Procedure |
| | Starter/generator failed | See the Starter/Generator (Starter Function) Test Procedure |
| | Starter solenoid failed | See the Solenoid Test Procedure |
| | Accelerator pedal limit switch failed | See the Throttle Position Switch Test Procedure |
| | Key switch failed | See the Key Switch (Start Circuit) Test Procedure |
| | Transaxle limit switch failed | See the Transaxle Limit Switch Test Procedure |
| | Loose or broken wire in starter/generator circuit | See Starter/Generator in the Electrical Components Section |
| | Cylinder and/or crankcase flooded with fuel | See the Fuel System Section |
| Starter/generator does not charge battery. | Loose or broken wire in the starter/ generator circuit | See the Starter/Generator (Generator Function) Test Procedure |
| | Generator field coil is shorted | See the Starter/Generator (Generator Function) Test Procedure |
| | Brushes are worn or commutator is dirty | See Starter/Generator in the Electrical Components Section |
| | Starter/generator belt is loose or slipping | See Belt Tension Adjustment For EFI Engines in the Electrical Components Section |
| | Voltage regulator failed | See the Voltage Regulator Test Procedure |
| | Battery failed | See the Battery Test Procedure |
| Transmission does not engage or disengage smoothly. | Transmission shifter linkage is binding or is out of adjustment | See the Transaxle (ED65) Section |
| | Insufficient (low) level of lubricant or wrong type of lubricant in transmission | See the Transaxle (ED65) Section |
| | Internal gears are damaged or worn | See the Transaxle (ED65) Section |
| | Dog clutch jammed or broken | See the Transaxle (ED65) Section |

TABLE CONTINUED ON NEXT PAGE

| TROUBLESHOOTING GUIDE | | |
|--|--|--|
| SYMPTOM | POSSIBLE CAUSES | CORRECTIVE ACTION |
| Excessive vehicle vibration. | Engine mounting nuts or bolts are loose | See the Engine (Kohler ECH440) Section |
| | Snubber on frame is worn or damaged | See the Engine (Kohler ECH440) Section |
| | Loose muffler mounting hardware | See the Exhaust System: Gasoline Vehicles Section |
| | Damaged drive belt or starter belt | See the Clutches: Gasoline Vehicles Section |
| | Damaged drive clutch | See the Clutches: Gasoline Vehicles Section |
| | Damaged starter/generator pulley | See Starter/Generator in the Electrical Components Section |
| | RPM setting is incorrect | See Engine RPM Adjustment in the Fuel System Section |
| Clutches do not shift smoothly. | Drive belt is worn, cracked, glazed, or frayed | See the Clutches: Gasoline Vehicles Section |
| | Drive clutch malfunction | See the Clutches: Gasoline Vehicles Section |
| | Governor is sticking | See the Transaxle (ED65) Section |
| Engine won't stop running. | Accelerator pedal linkage out of adjustment causing engine kill limit switch not to activate | See the Fuel System: Gasoline Vehicles Section |
| | Fuel mixture is too lean; check EFI | See the Fuel System: Gasoline Vehicles Section |
| | Throttle stop screw out of adjustment at governor arm | See the Fuel System: Gasoline Vehicles Section |
| Vehicle with Visage Only - Vehicle operates in reverse, but not forward. | Gas car stop module is bad. | <ol style="list-style-type: none"> 1. Disconnect the main harness from the gas car stop module. 2. Connect the main harness directly to the pedal position sensor on the pedal. 3. If the vehicle operates in both forward and reverse, replace the gas car stop module. <p>NOTE: Visage will not operate correctly with the main harness connected directly to the pedal position sensor.</p> |

FUSE AND RELAY LOCATIONS

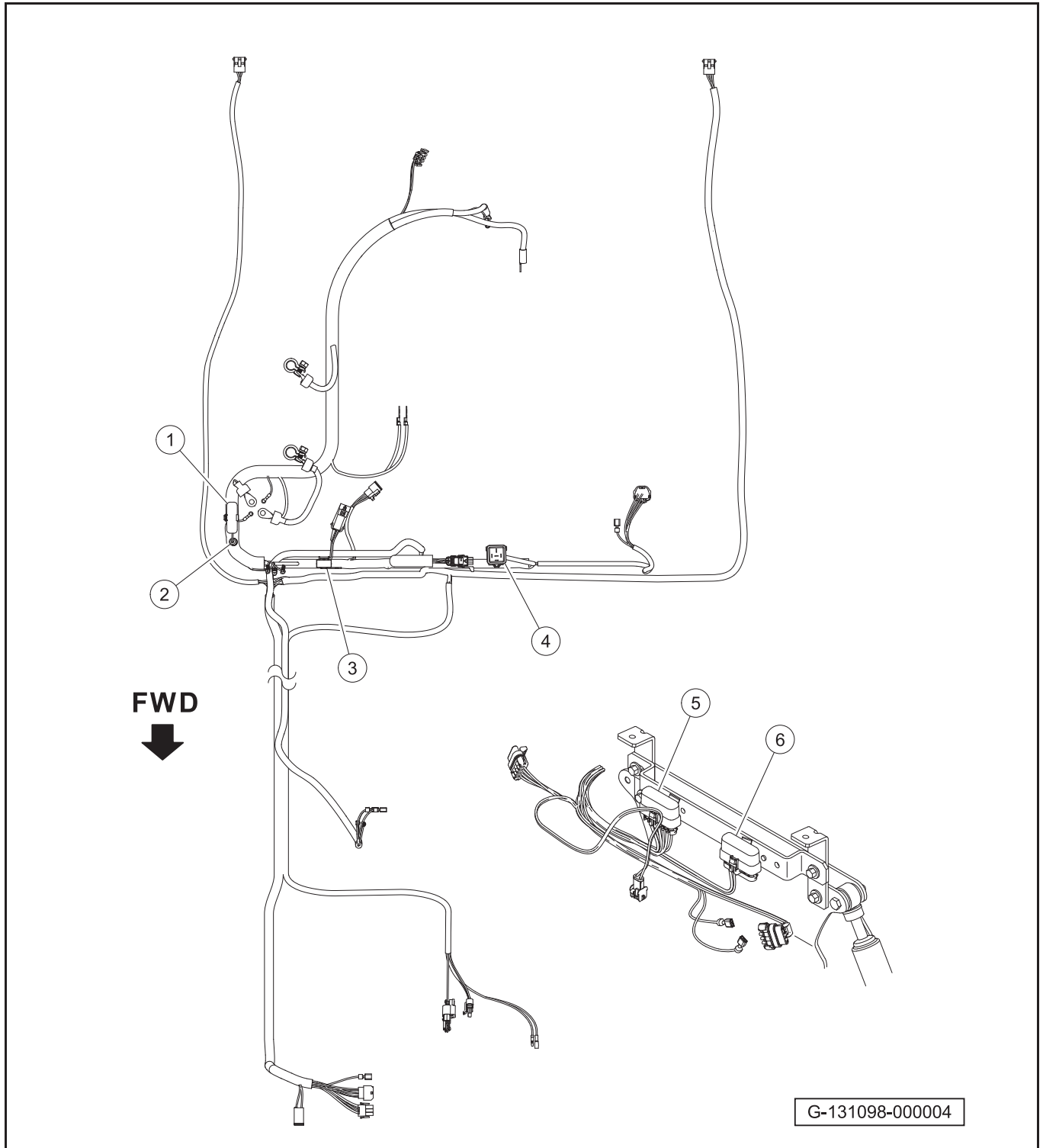


Figure 19-2 Fuse and Relay Locations

See Fuse and Relay Locations on page 19-5.

| CALLOUT NUMBER | DESCRIPTION |
|----------------|---|
| 1 | Fuse Holder <ul style="list-style-type: none"> • 10A Fuse • 5A Fuse • 20A Fuse |
| 2 | 2A Fuse |
| 3 | 15A Fuse |
| 4 | Fuel Pump Relay |
| 5 | Fuse Holder <ul style="list-style-type: none"> • 7.5A Fuse - Stereo, Visage • 4A Fuse - Accent/Logo • 3A Fuse - Headlights, Taillights |
| 6 | Fuse Holder <ul style="list-style-type: none"> • 10A Fuse - Horn, Turn Signal |

ELECTRICAL SYSTEM

The electrical system on the gasoline vehicle is 12 volts DC with negative (–) ground to frame, and consists of the following circuits that are easily identified:

- Starter Circuit
- Generator Circuit
- Electronic Fuel Injection Circuit
- Engine Ignition Circuit
- Engine Kill Circuit
- Multi-purpose Buzzer Circuit
- Low Oil Warning Light Circuit
- Neutral Lockout Circuit
- Fuel Pump Circuit
- Fuel Gauge and Sending Unit Circuit
- Hour Meter Circuit
- Lighting Circuit

Recognizing and understanding the function of each of these circuits will help to quickly isolate the source of an electrical problem. Use the appropriate test procedure to correct the electrical problem. **See Test Procedures on page 19-7.**

TEST PROCEDURES

Using the following procedures, the entire electrical system can be tested without major disassembly of the vehicle.

⚠ WARNING

- If wires are removed or replaced, make sure wiring and wire harness is properly routed and secured. Failure to properly route and secure wiring could result in vehicle malfunction, property damage, personal injury, or death.

For some tests, the electrical component box cover must be removed to gain access to the various components that are mounted inside the component box. **See following WARNING.**

⚠ WARNING

- Shorting of battery terminals can cause personal injury or death.

After test procedures are completed, be sure to replace the cover. **See following CAUTION.**

CAUTION

- Exposure to water and the elements may damage electrical components. Do not operate vehicle without the cover properly installed.

TESTING BASICS

- Battery voltage will be referenced throughout the test procedures. Battery voltage is accessed in the Battery test procedure.
- The Maintenance/Operate switch, in the MAINTENANCE position, grounds and kills the ignition if the Forward/Neutral/Reverse control (FNR) is placed in F or R.
- The key switch powers the ECU, fuel pump, solenoid, lights, and the connected car device.
- The 2-amp fuse is powered by the key switch via the 10-amp ATM fuse and carries battery voltage to the connected car device.
- The term “back-probe” refers to probing the side of a connector that the wire enters. This is usually done when the connector must remain connected to a device. An alternative method is to use an insulation-piercing probe. **See following CAUTION.**

CAUTION

- Be careful not to damage the wire or terminal when back-probing.
- When testing voltage, the battery must remain connected.
- When testing voltage, unless specifically directed to do otherwise in a procedure, connect the black (–) probe of the multimeter to chassis ground.
- When testing resistance or continuity, turn off power to the circuit being measured and discharge any capacitor. The presence of voltage can cause inaccurate readings.

Index of Test Procedures

- 1 – Battery
- 2 – Fuse Inspection
- 3 – Ground Cables
- 4 – Key Switch (Start Circuit)
- 5 – Key Switch (Engine Kill Circuit)
- 6 – Throttle Position Sensor (TPS)
- 7 – Solenoid
- 8 – Maintenance/Operate Switch
- 9 – Transaxle Limit Switch
- 10 – Starter/Generator (Generator Function)
- 11 – Starter/Generator (Starter Function)
- 12 – Voltage Regulator
- 13 – Ignition Spark
- 14 – Multi-Purpose Buzzer and Multi-Purpose Buzzer Limit Switch
- 15 – Malfunction Indicator Light (MIL)
- 16 – Low Oil Warning Light (LED)
- 17 – Battery Test (Under Load)
- 18 – Fuel Pump
- 19 – Fuel Level Sending Unit
- 20 – Fuel Gauge
- 21 – Hour Meter
- 22 – 4-Pin Connector (to Visage)

TEST PROCEDURE 1 – Battery

⚠ DANGER

- Due to the danger of an exploding battery, wear a full face shield and rubber gloves when working near a battery.
- Battery – Explosive gases! Do not smoke. Keep sparks and flames away from the vehicle and service area. Ventilate when charging or operating vehicle in an enclosed area. Wear a full face shield and rubber gloves when working on or near batteries.
- Battery – Poison! Contains acid! Causes severe burns. Avoid contact with skin, eyes, or clothing. Antidotes:
 - External: Flush with water. Call a physician immediately.
 - Internal: Drink large quantities of milk or water. Follow with milk of magnesia or vegetable oil. Call a physician immediately.
 - Eyes: Flush with water for 15 minutes. Call a physician immediately.

NOTE: The battery must be properly maintained and fully charged in order to perform the following test procedures. Battery maintenance procedures can be found in the Electrical Components: Pedal-Start Gas Vehicle section.

1. Disable the vehicle.
2. Set the Maintenance/Operate switch to MAINTENANCE.
3. Check for loose or corroded battery terminal connections.
4. Disconnect the battery.
5. Clean the battery terminals and connections. Replace the connections and wires as necessary.
6. Connect the battery.

Voltage Test

1. Set the multimeter to 20 VDC.
2. Put the red (+) probe on the positive (+) battery post.
3. Put the black (-) probe on the black (-) battery post.
- 3.1. If the voltage is more than 12.4 volts, the battery is good.
- 3.2. If the voltage is less than 12.4 volts, charge the battery. Go to step 3.2.1.
- 3.2.1. If the voltage does not reach 12.4 volts after charging, replace the battery.

Load Test

1. Make a note of the ambient temperature.
2. Connect a 160-ampere load tester to the battery posts.
3. Turn the switch on the load tester to the ON position.
4. Wait for 15 seconds. Read the battery voltage. Compare the battery's voltage reading with the following table.

| IF TEMPERATURE IS | MINIMUM CRANKING VOLTAGE |
|-------------------------|--------------------------|
| 70 °F (20 °C and above) | 9.6 V |
| 60 °F (16 °C) | 9.5 V |
| 50 °F (10 °C) | 9.4 V |
| 40 °F (4 °C) | 9.3 V |
| 30 °F (-1 °C) | 9.1 V |
| 20 °F (-7 °C) | 8.9 V |
| 10 °F (-12 °C) | 8.7 V |
| 0 °F (-18 °C) | 8.5 V |

5. If the battery voltage is less than the minimum cranking voltage, replace the battery.
- 5.1. If the electrical problem continues, test the electrical circuits.
6. If the battery voltage is the minimum cranking voltage or higher, test the electrical circuits.

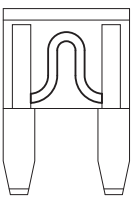
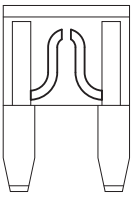
TEST PROCEDURE 2 – Fuse Inspection

See General Warnings on page 1-2.

⚠ WARNING

- Failure to use properly rated fuse can result in a fire hazard.

1. Disable the vehicle.
2. Remove the fuse.
3. Examine the fuse. Replace as necessary.

| | |
|------------|---|
| Good Fuse |  <small>G-130998-000004</small> |
| Blown Fuse |  <small>G-130998-000005</small> |

TEST PROCEDURE 3 – Ground Cables

See General Warnings on page 1-2.

NOTE: This is a continuity test for the main ground wire of the vehicle. An additional ground wire is located on top of the fuel tank.

1. If necessary, see Testing Basics.
2. Disconnect battery and spark plug wire.
3. Check the following wires and cables for clean, tight connections and continuity:
 - Check the starter/generator ground cable (black wire) from A1 terminal to chassis or engine.
 - Check the engine ground cable from engine block to negative (-) main harness lead disconnected from battery.
 - Check the ground cable from main harness to negative (-) main harness lead disconnected from battery.
 - Disconnect voltage regulator from main harness. Check from black wire in 3-pin connector to negative (-) main harness lead disconnected from battery. This will test sonic weld _18 and sonic weld _1 in the main wire harness.
4. The reading should be continuity. If the reading is incorrect, clean and tighten cable connections. If the connections are good and the reading is incorrect, repair or replace the wire or cable.

TEST PROCEDURE 4 – Key Switch (Start Circuit)

See General Warnings on page 1-2.

NOTE: This is a voltage test.

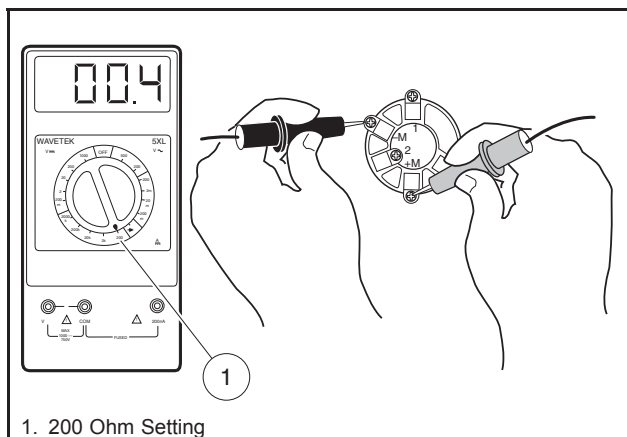
The key switch provides power and KEY INPUT to the ECU.

1. If necessary, see Testing Basics.
2. Remove the instrument panel. Do not disconnect the wires.
3. With the key switch in the OFF position:
 - The red wire should show battery voltage coming to the switch.
 - The blue wire should show zero (0) volts. If it shows battery voltage, the switch has failed CLOSED and must be replaced.
4. With the key switch in the ON position:
 - The blue wire should show battery voltage. If it does not show battery voltage, the switch has failed OPEN and must be replaced.

TEST PROCEDURE 5 – Key Switch (Engine Kill Circuit)

NOTE: This is a continuity test.

1. If necessary, see Testing Basics.
2. Disconnect battery and spark plug wire.
3. Remove the instrument panel. See Instrument Panel Removal.
4. Disconnect the wires from the (+M) and (–M) terminals of the key switch.
5. Set the multimeter to 200 Ohm (1) (Figure 19-3, Page 19-12).



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Figure 19-3 Key Switch Test – Engine Kill Circuit

6. Put the red (+) probe on the (+M) terminal.
7. Put the black (–) probe on the (–M) terminal.
8. With the key switch OFF, the reading should be continuity.
 - 8.1. If there is no continuity, replace the key switch.
9. With the key switch ON, the reading should be no continuity.
 - 9.1. If there is continuity, replace the key switch.
10. Connect the wires to the key switch. Make sure wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
11. Install the instrument panel. See Instrument Panel Installation.

TEST PROCEDURE 6 – Throttle Position Sensor (TPS)

The throttle position sensor performs the function of two limit switches: the accelerator pedal limit switch and the kill limit switch. This sensor is sealed and is not to be repaired or replaced. If sensor is determined to need replacing through test procedures found in this manual, the accelerator pedal assembly must be replaced. See Accelerator Pedal Removal. The sensor is joined to the main wire harness through a six-pin connector. Tests for the sensor are found in the following two procedures.

Accelerator Pedal Limit Switch Function

See General Warnings on page 1-2.

The green and orange wires connect to the accelerator pedal limit switch function of the throttle position sensor. This is the normally open (NO) portion of the circuit used to energize the starter solenoid.

NOTE: Keep the battery connected while performing this test procedure.

1. Set the Maintenance/Operate switch to MAINTENANCE.
2. Disconnect the spark plug wire.
3. Disconnect gray 18-pin connector from ECU.
4. Set the multimeter to the diode test function.
5. Attach the red (+) lead to the orange wire at the starter solenoid.
6. Attach the black (–) lead to the green wire at the limit switch located on the Forward/Neutral/Reverse control (FNR). **See following NOTE.**

NOTE: It may be necessary to partially pull the green wire from the switch terminal to attach the black lead.

7. Turn the key switch to the ON position.
8. **With accelerator pedal in the up position:** The meter should indicate an over limit (no continuity) condition. If the reading is incorrect, replace the accelerator pedal assembly.
9. **With accelerator pedal pressed:** The meter should indicate approximately 1.0 volt. If the reading is incorrect, replace the accelerator pedal assembly.

Kill Limit Switch Function

See General Warnings on page 1-2.

The black and white/black wires connect to the kill limit switch function of the throttle position sensor. This is the normally closed (NC) portion of the circuit used to ground the ignition and shut the engine off when the pedal is released.

NOTE: Keep the battery connected while performing this test procedure.

1. Set the Maintenance/Operate switch to MAINTENANCE.
2. Disconnect the spark plug wire.
3. Disconnect gray 18-pin connector from ECU.
4. Set the multimeter to the diode test function.
5. Attach the red (+) lead to the negative (-) battery terminal.
6. Attach the black (-) lead to the white/black wire at the limit switch located on the Forward/Neutral/Reverse control (FNR). **See following NOTE.**

NOTE: It may be necessary to partially pull the white/black wire from the switch terminal to attach the black lead.

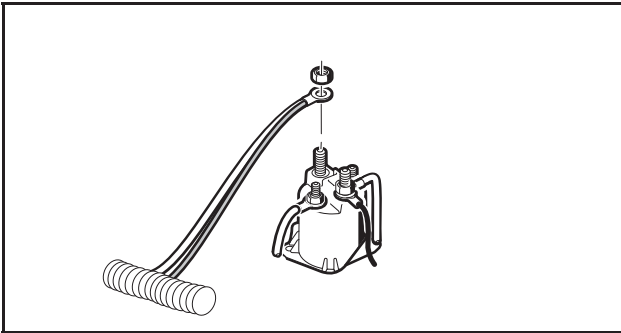
7. Turn the key switch to the ON position.
8. **With accelerator pedal in the up position:** The meter should indicate approximately 1.0 volt. If the reading is incorrect, replace the accelerator pedal assembly.
9. **With accelerator pedal pressed:** The meter should indicate an over limit (no continuity) condition. If the reading is incorrect, replace the accelerator pedal assembly.

TEST PROCEDURE 7 – Solenoid

See General Warnings on page 1-2.

NOTE: This is a resistance and voltage test.

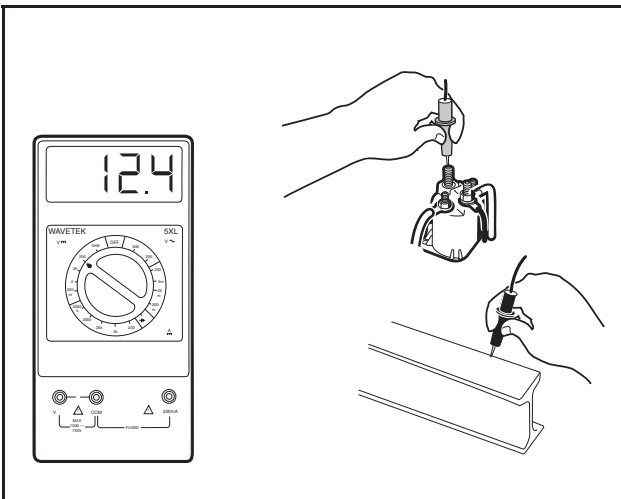
1. If necessary, see Testing Basics.
2. Make sure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
3. **Coil Side:** Check the resistance across the small posts of the solenoid. The reading should be 14 to 16 ohms. If the reading is not within limits, replace the solenoid.
4. **Contact Side:** Remove the white wire and 16-gauge red wire from the large post of the solenoid (**Figure 19-4, Page 19-14**). Do not let the wires touch the frame or other components of the vehicle. Cover the other large post.



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Figure 19-4 Solenoid Wire Removal

- 4.1. Set the Forward/Neutral/Reverse control (FNR) to N.
- 4.2. Set the Maintenance/Operate switch to MAINTENANCE.
- 4.3. Set the key switch to ON.
- 4.4. Check voltage between the empty large post and ground (**Figure 19-5, Page 19-14**).



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Figure 19-5 Solenoid Ground Test

- **With accelerator pedal in the up position:** The meter should read no voltage. If the reading is incorrect, replace the solenoid.

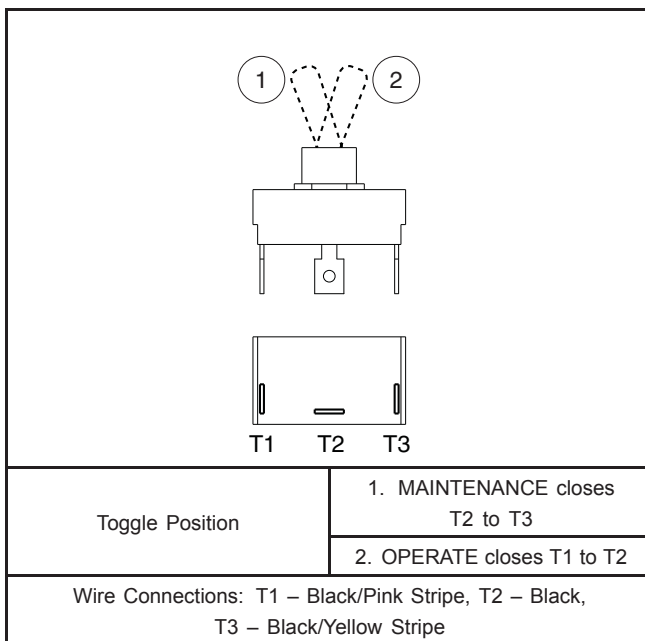
- **With accelerator pedal pressed:** The solenoid should click and the meter should read battery voltage. If the reading is incorrect, replace the solenoid.

TEST PROCEDURE 8 – Maintenance/Operate Switch

NOTE: This is a continuity test.

The Maintenance/Operate Switch is also known as the Neutral Lockout Switch.

1. If necessary, see Testing Basics.
2. Remove the wires from switch.



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Figure 19-6 Maintenance/Operate Switch Test

3. Set the switch to MAINTENANCE (1) (**Figure 19-6**):
 - 3.1. Check for no continuity between terminals T1 and T2. If there is continuity, replace the switch.
 - 3.2. Check for continuity between terminals T2 and T3. If there is no continuity, replace the switch.
4. Set the switch to OPERATE (2):
 - 4.1. Check for no continuity between terminals T2 and T3. If there is continuity, replace the switch.
 - 4.2. Check for continuity between terminals T1 and T2. If there is no continuity, replace the switch.
5. If the switch works as stated and the MAINTENANCE/OPERATE modes still do not work:
 - 5.1. Check the limit switches.
 - 5.2. Check continuity of the wires involved.

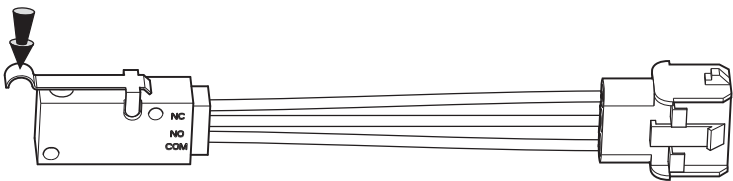
TEST PROCEDURE 9 – Transaxle Limit Switch

See General Warnings on page 1-2.

NOTE: This is a continuity test.

This switch is located on the transaxle. A black/pink wire, a red wire, and a gray wire are connected to this limit switch with a 3-pin connector.

1. If necessary, see Testing Basics.
2. Disconnect battery and spark plug wire.
3. At the transaxle, disconnect transaxle limit switch three-wire lead from main wire harness.
4. Make sure that the cam lobe on the shift lever is pressing the transaxle limit switch as the Forward/Neutral/Reverse control (FNR) is being shifted.
- 4.1. If the transaxle limit switch does not make an audible click as it is pressed, check for wear on the cam lobe and replace shift lever if necessary.
5. Check the following terminals for no continuity with the lever released and continuity with the lever engaged (**Figure 19-7, Page 19-16**):

|  | |
|---|---|
| PROBE BETWEEN LOCATIONS | TEST RESULT |
| Between terminal 1 "COM" (black/pink wire) and terminal 2 "NO" (gray wire) | With lever released: No continuity |
| | With lever pressed: Continuity |
| Between terminal 1 "COM" (black/pink wire) and terminal 3 "NC" (red wire) | With lever released: Continuity |
| | With lever pressed: No continuity |

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Figure 19-7 Transaxle Limit Switch Test

6. If transaxle limit switch does not work as stated in previous step, replace the transaxle limit switch.

TEST PROCEDURE 10 – Starter/Generator (Generator Function)

NOTE: This is a voltage test.

1. If necessary, see Testing Basics.
2. Disable the vehicle.
3. Set the Maintenance/Operate switch to MAINTENANCE.
4. Make sure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
5. Disconnect the yellow wire (1) from the DF terminal (2) on starter/generator (**Figure 19-8**).

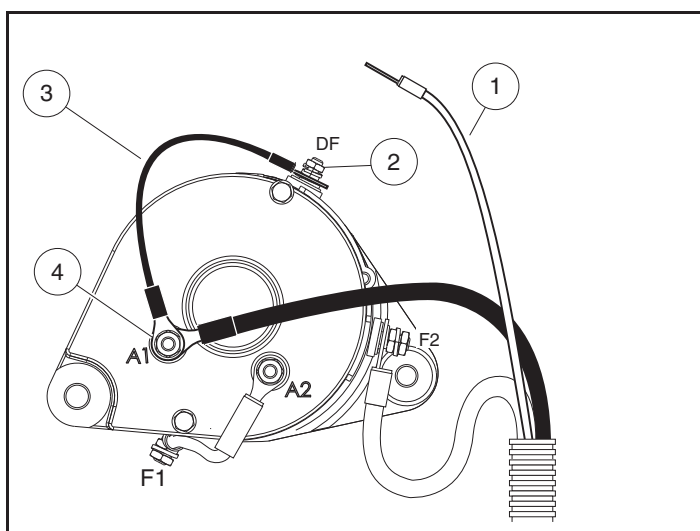


Figure 19-8 Jumper Wire Ground – DF to A1

6. Cover terminal on yellow wire to make sure it will not short to ground.
7. Use a jumper wire (3) to ground DF terminal to A1 terminal (4).
8. Set the multimeter 20 VDC.
9. Put the red (+) probe on the positive (+) post of the battery.
10. Put the black (–) probe on the negative (–) post.
11. Start the engine and run it at full governed speed. The reading should show the voltage rising on the meter.
 - 11.1. If the voltage rises above 15.3 volts DC, test the voltage regulator.
 - 11.2. If the voltage does not rise, do a tear-down inspection of the starter/generator.
12. Remove the jumper wire.
13. Reconnect the yellow wire to the DF terminal on starter/generator.

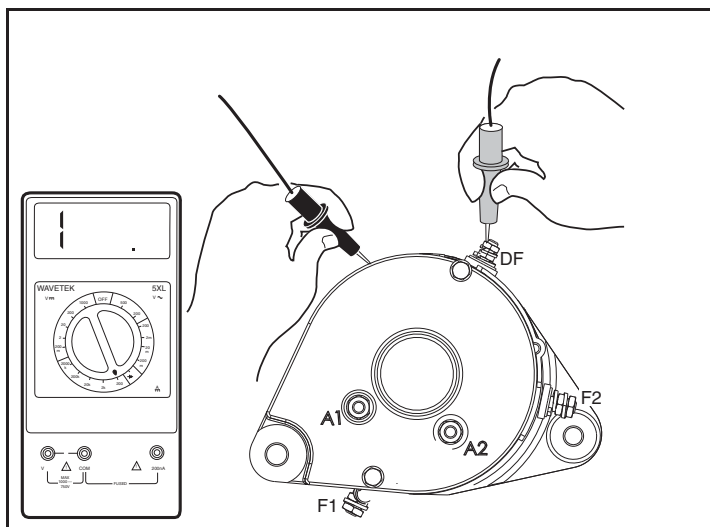
TEST PROCEDURE 11 – Starter/Generator (Starter Function)

NOTE: Observe the following before testing the starter/generator:

- This is only testing continuity.
- Tag the starter/generator wires for identification before disconnecting.
- Remove starter/generator wire from one of the “A” terminals and one of the “F” terminals if testing while starter/generator is in vehicle.
- When disconnecting wires from starter/generator terminals, use a second wrench on the lower nut of the terminal post to hold post steady.
- Scrape a small amount of paint from starter/generator housing (ground) and use this location when testing motor terminals to electrical ground.

| MOTOR TERMINALS | CONTINUITY TEST RESULT |
|------------------------------|---------------------------|
| A1 to A2 F1 to F2 | Continuity |
| A1 to F1 A1 to F2 | No Continuity |
| A2 to F1 A2 to F2 | No Continuity |
| A1 to Ground A2 to Ground | No Continuity |
| F1 to Ground F2 to Ground | No Continuity |

1. If necessary, see Testing Basics.
2. Disconnect the battery and spark plug wire.
3. Disconnect the wires from all the terminals on the starter/generator.
4. Set the multimeter to 200 Ohms.
5. Put the black (–) probe on the starter/generator housing. Scratch through the finish to ensure a good ground.



3030B

Figure 19-9 Check Starter Terminal Continuity

6. Put the red (+) probe (one at a time) on the A1, A2, F1, F2 and DF terminals. The readings should be no continuity.
- 6.1. If there is continuity, the starter/generator will need to be removed from the vehicle and disassembled by a qualified technician.
7. Put the red (+) probe on the A1 terminal and the black (–) probe on the A2 terminal. The reading should be continuity.

- 7.1. If there is no continuity, the starter/generator will need to be removed from the vehicle and disassembled by a qualified technician.

Possible causes:

- A grounded wire in the brush area.
- A grounded armature/commutator.
- A grounded A1 or A2 terminal.

8. Put the red (+) probe on the F1 terminal and the black (–) probe on the F2 terminal. The reading should be between approximately 0.1 and 0.3 ohms.

- 8.1. If the reading is incorrect, the starter/generator will need to be removed from the vehicle and disassembled by a qualified technician.

Possible causes:

- A grounded F1 or F2 terminal or a grounded field coil.

9. Put the red (+) probe on the DF terminal and the black (–) probe on the F1 terminal. The reading should be between 4.5 and 5.5 ohms.

- 9.1. If the reading is incorrect, the starter/generator will need to be removed from the vehicle and disassembled by a qualified technician.

Possible causes:

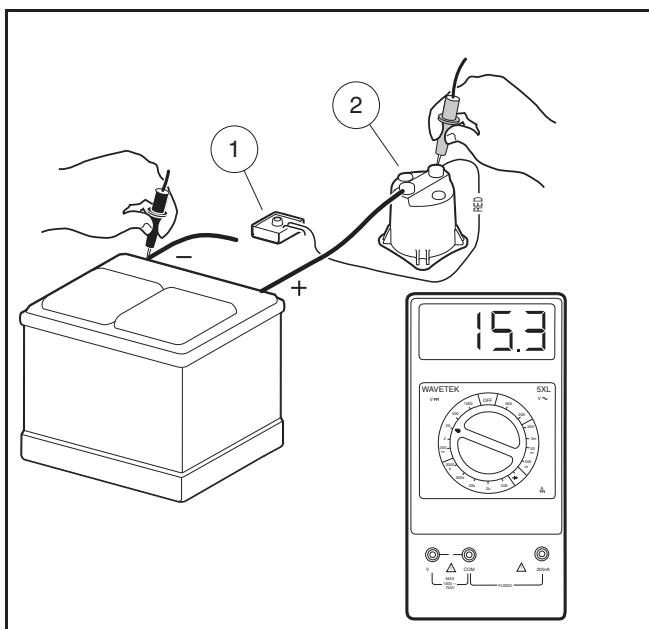
- A grounded DF terminal or a grounded field coil.

10. Make sure that wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.

TEST PROCEDURE 12 – Voltage Regulator

NOTE: This is a voltage test. Keep the battery connected while performing this test procedure.

1. If necessary, see Testing Basics.
2. Disable the vehicle.
3. Set the Maintenance/Operate switch to MAINTENANCE.
4. Make sure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
5. Check the engine RPM setting to make sure that it is adjusted correctly.
6. Make sure that the battery is good and fully charged.
7. Turn the key switch to ON.
8. Operate the engine for several minutes to bring the voltage regulator to operating temperature.
9. Turn the key switch to OFF position.
10. Make sure that the red wire from the voltage regulator (1) is connected to the solenoid (2).



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Figure 19-10 Voltage Regulator Test

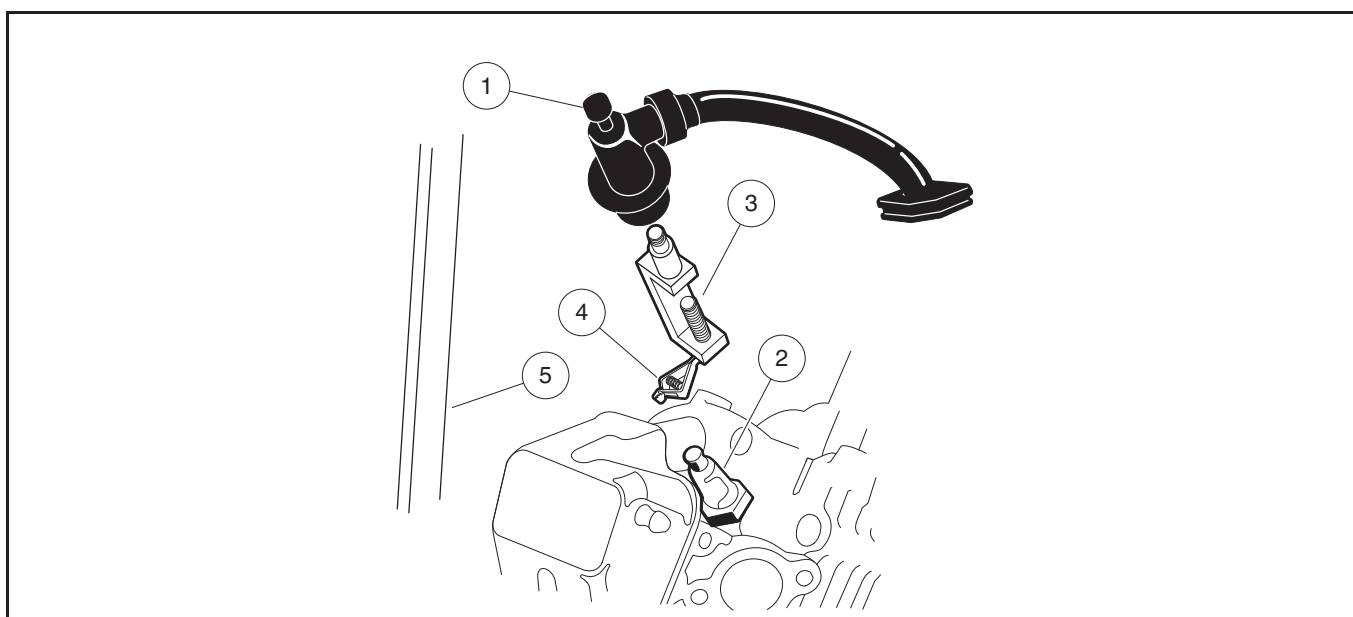
11. Set the multimeter to 20 VDC.
12. Put the red (+) probe on the large post of the solenoid.
13. Put the black (–) probe on the negative (–) battery post.
14. Turn the key switch to the ON position.
15. Press the accelerator to start the engine and run it at full governed speed.
 - 15.1. If the reading is between 14.7 and 15.3 volts, the voltage regulator is good.
 - 15.2. If the reading is over 15.3 volts and continues to rise, replace the voltage regulator.
 - 15.3. If the reading is lower than 14.7 volts but rising steadily, check the battery condition.
 - 15.4. If the reading is lower than 14.7 volts and not rising, check the starter/generator.
 - 15.4.1. If the starter/generator is good, replace the voltage regulator.

TEST PROCEDURE 13 – Ignition Spark

NOTE: Keep the battery connected while performing this test procedure.

Use an spark gap test tool (Thexton 404® or equivalent)

1. If necessary, see Testing Basics.
2. Disable the vehicle.
3. Set the Maintenance/Operate switch to MAINTENANCE.
4. Remove the spark plug wire (1) from the spark plug (2) (**Figure 19-11, Page 19-21**).



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Figure 19-11 Ignition Spark Test

5. Adjust the spark gap test tool (3) probes to approximately 18,000 volts (18 kV) setting (SE – *Small Engine Setting* on the Thexton 404® tool).
6. Connect the ignition spark gap test tool to the spark plug wire.
7. Connect the alligator clip (4) to a solid engine ground (5).
8. Start the engine.
 - 8.1. If the spark gap test tool has no spark, test the ignition circuit.
 - 8.2. If the spark gap test tool has a faint yellow or red color, test the ignition circuit.
 - 8.3. If the spark gap test tool has a strong blue spark, check the spark plug gap.
 - 8.3.1. If the spark plug gap is correct, replace the spark plug.

TEST PROCEDURE 14 – Multi-Purpose Buzzer and Multi-Purpose Buzzer Limit Switch

NOTE: Multi-purpose Buzzer: This is a voltage test.

A multi-purpose buzzer is mounted on the back side of the instrument panel. On some models, another multi-purpose buzzer is also mounted on a bracket at the left rear of the vehicle. The multi-purpose buzzer is powered by the 10-amp ATM fuse.

1. If necessary, see Testing Basics.
2. Remove the instrument panel.
3. Check for proper wiring and tight connections.
4. Turn the key switch to ON.
5. Check that battery voltage is present in the red/white wire at multi-purpose buzzer.
 - 5.1. If there is no battery voltage, check the 10-amp ATM fuse.
6. Set the Forward/Neutral/Reverse control (FNR) to R.
 - 6.1. If the multi-purpose buzzer does not sound, check the multi-purpose buzzer limit switch.
7. Turn the key switch to OFF.

NOTE: Multi-purpose Buzzer Limit Switch: This is a continuity test.

The multi-purpose buzzer limit switch is located on the FNR. Red/white and orange wires are connected to it.

1. Disconnect the black wire from the multi-purpose buzzer.
2. Set the FNR to R.
3. Check for continuity between the black wire and ground.
 - 3.1. If there is no continuity, replace the multi-purpose buzzer limit switch.
 - 3.2. If there is continuity, go to step 4.
4. Set the FNR to F.
5. Check for continuity between the black wire and ground.
 - 5.1. If there is continuity, replace the multi-purpose buzzer limit switch.
 - 5.2. If there is no continuity, replace the multi-purpose buzzer.

TEST PROCEDURE 15 – Malfunction Indicator Light (MIL)

NOTE: *This is a voltage test.*

1. If necessary, see Testing Basics.
2. Remove the instrument panel.
3. Make sure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
4. Turn the key switch to ON.
5. Check for battery voltage at red/white wire to malfunction indicator light (MIL).
 - 5.1. If there is no voltage, check the key switch.
 - 5.2. If there is battery voltage, use a test lead to ground the tan wire terminal of the MIL.
 - 5.2.1. If the light illuminates, the MIL is good.
 - 5.2.2. If the light does not illuminate, replace the MIL.

TEST PROCEDURE 16 – Low Oil Warning Light (LED)

NOTE: *This is a voltage test.*

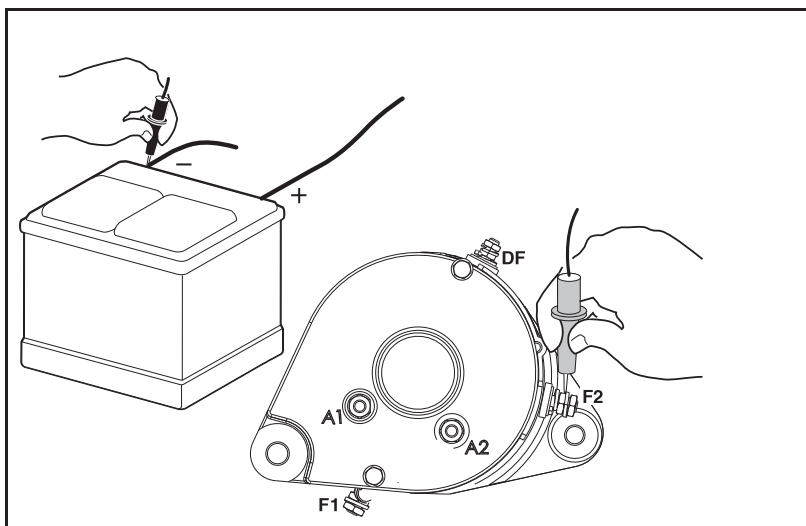
1. If necessary, see Testing Basics.
2. Remove the instrument panel.
3. Make sure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
4. Turn the key switch to ON.
5. Check for battery voltage at yellow/white wire to low oil warning light.
 - 5.1. If there is no voltage, check the key switch.
 - 5.2. If there is battery voltage, use a test lead to ground the yellow wire terminal of the low oil warning light.
 - 5.2.1. If the light illuminates, the low oil warning light is good.
 - 5.2.2. If the light does not illuminate, replace the low oil warning light.

TEST PROCEDURE 17 – Battery Test (Under Load)

NOTE: Keep the battery connected while performing this test procedure.

The voltage reading listed is for electrolyte at 70 °F (21 °C). At lower electrolyte temperatures the voltage reading will be lower.

1. If necessary, see Testing Basics.
2. Set the Forward/Neutral/Reverse control (FNR) to N.
3. Set the Maintenance/Operate switch to MAINTENANCE.
4. Put chocks against the wheels.
5. Set a multimeter to 20 VDC.
6. Put the red (+) probe on the F2 (white wire) terminal on the starter/generator (**Figure 19-12**).



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Figure 19-12 Battery Test (Under Load)

7. Put the black (–) probe on the negative (–) battery post.
8. Turn the key switch to ON.
9. Make sure that the FNR is in N, and push the accelerator pedal.

NOTE: With the accelerator pedal pushed, the battery is under load.

- 9.1. If the voltage reading is over 9.6 volts, with an electrolyte temperature of 70 °F (21 °C), check the starter/generator.
- 9.2. If the reading is below 9.6 volts, with an electrolyte temperature of 70 °F (21 °C), check the battery.
- 9.3. If the reading is zero, there may be no continuity across the large posts of the solenoid. Check the solenoid.
- 9.4. If all of the test results are good and the voltage reading is zero, there may be a broken or damaged white wire from the solenoid to the starter/generator.
10. If all of the test results are good and the voltage reading is zero, there may be a broken or damaged white wire from the solenoid to the starter/generator.

TEST PROCEDURE 18 – Fuel Pump

⚠ WARNING

- To avoid the possibility of fire or explosion, make sure the fuel tank cap is securely in place while performing this test procedure.

NOTE: This is a voltage and resistance test.

Voltage to Fuel Pump

1. If necessary, see Testing Basics.
2. Check the 10 amp fuse in the fuel pump circuit.
 - 2.1. If the 10 amp fuse is bad, replace the fuse.
 - 2.2. If the 10 amp fuse is good, go to step 3.
3. Disconnect the fuel pump connector from the top of the fuel pump module.
4. Set the Maintenance/Operate switch to MAINTENANCE.
5. Put chocks against the wheels.
6. While the engine is running, check for battery voltage between ground and the pin 5 of the fuel pump connector.

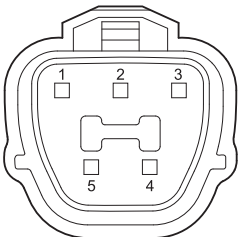
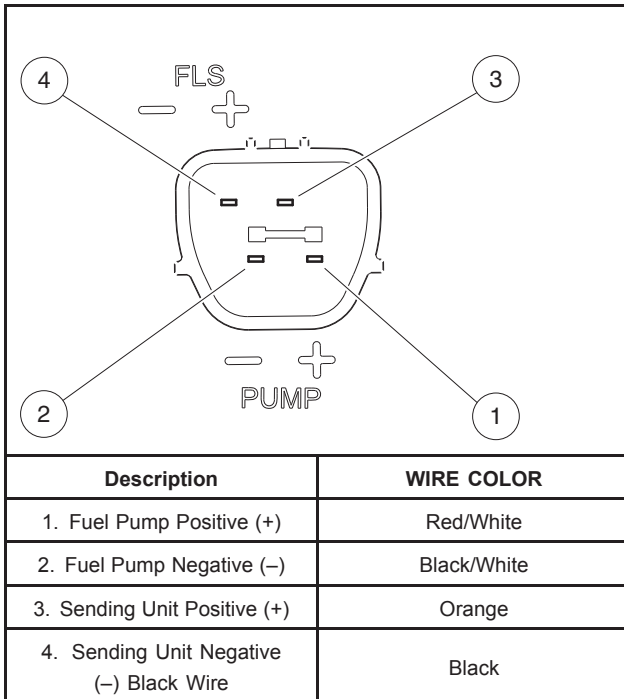
|  | | |
|---|-------------|---------------------------|
| Pin | Wire Color | Description |
| 1 | Open | Open |
| 2 | Orange | Sending Unit Positive (+) |
| 3 | Black | Sending Unit Negative (-) |
| 4 | Black/White | Fuel Pump Negative (-) |
| 5 | Red/White | Fuel Pump Positive (+) |

Figure 19-13 Fuel Pump Connector

- 6.1. If there is no voltage, check for battery voltage at the red wire of the fuel pump relay while the engine is running.
 - 6.1.1. If there is battery voltage, replace the fuel pump relay.
 - 6.1.2. If there is no battery voltage, check the key switch.
- 6.2. If there is voltage, check for battery voltage at the black/white wire of the fuel pump relay while the engine is running.
 - 6.2.1. If there is no voltage, replace the fuel pump relay.
 - 6.2.2. If there is voltage, check the fuel pump resistance.

Fuel Pump Resistance Procedure

1. If necessary, see Testing Basics.
2. Disconnect the battery.
3. Disconnect the fuel pump connector from the top of the fuel pump module.
4. Set the multimeter to 200 Ohms.
5. Check for approximately 2 to 5 ohms between pin (1) and pin (2) terminals in fuel pump module.



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Figure 19-14 Fuel Pump Module Terminals

- 5.1. If the reading indicates no resistance, the fuel pump has failed and the fuel pump module must be replaced.

5.2. If the reading is correct and the fuel pump does not function correctly, go to step 5.2.1. Leave the battery disconnected while checking continuity.

5.2.1. Check the continuity from the black/white wire of the fuel pump relay to pin (G) of the ECU connector.

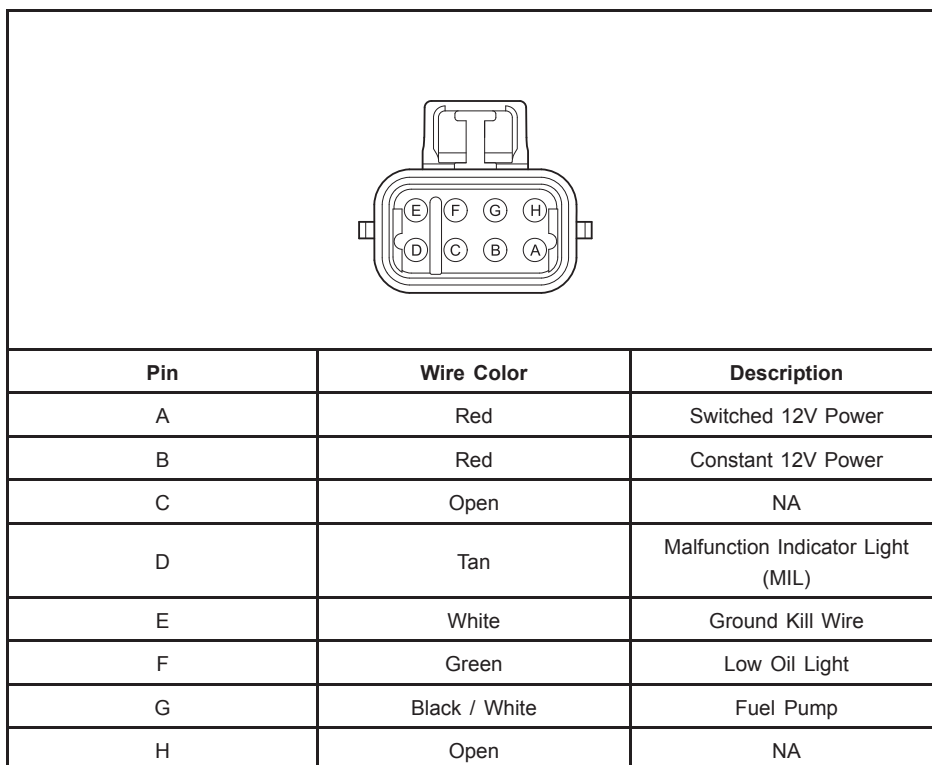


Figure 19-15 ECU Connector

TEST PROCEDURE 19 – Fuel Level Sending Unit

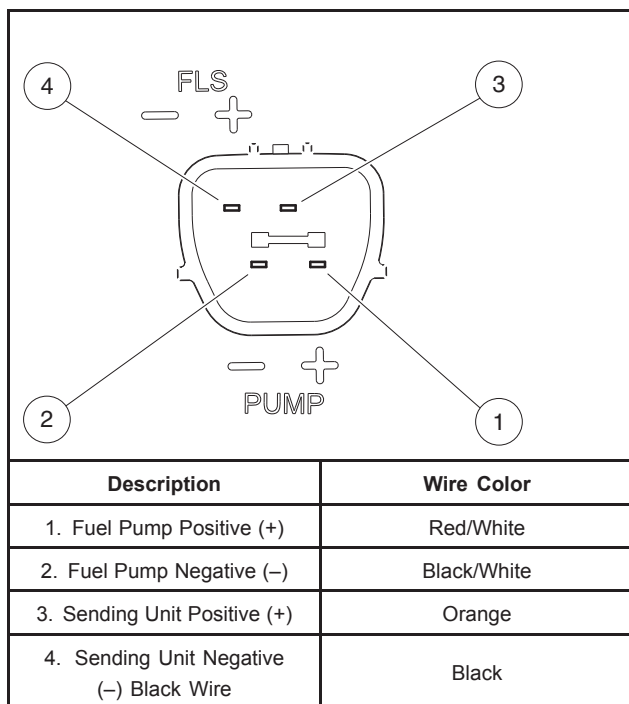
⚠ WARNING

- To avoid the possibility of fire or explosion, make sure the fuel tank cap is securely in place while performing this test procedure.

NOTE: This is a resistance test.

1. If necessary, see Testing Basics.
2. Disconnect the battery.
3. Disconnect the fuel pump connector from the top of the fuel pump module.

4. Check the resistance between pin (3) and pin (4) terminals in module.



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Figure 19-16 Fuel Pump Module Terminals

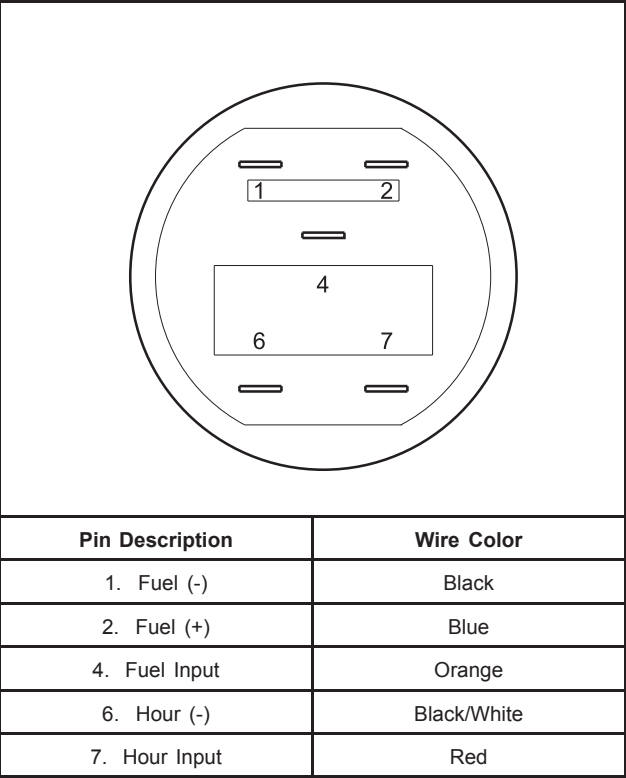
5. The following resistance readings (in ohms) should be obtained depending on the position of the float inside the fuel tank. The resistance reading will vary according to the exact position of the float. The chart below may be used as a guideline to determine if the fuel level sending unit is operating correctly. Make sure the float is at the surface of the fuel in the tank.

| FLOAT POSITION | RESISTANCE READING | FUEL GAUGE READINGS |
|----------------------------------|-----------------------|---------------------|
| Lower position (tank empty) | 250 ohms (± 10) | Empty |
| Center position (tank half full) | 141 ohms (± 8) | Half full |
| Upper position (tank full) | 33.3 ohms (± 6) | Full |

- 5.1. If the readings are within the specifications listed above, the fuel level sending unit is working properly.
- 5.2. If the readings are incorrect, the fuel level sending unit has failed and the fuel pump module must be replaced.
- 5.3. If the readings are correct and the fuel gauge does not function correctly, go to step 5.3.1. Leave the battery disconnected while checking continuity.
- 5.3.1. Check the continuity of the orange wire from the fuel level sending unit to the orange wire on the fuel gauge/hour meter.
- 5.3.2. Check the continuity of the red/white wire from the fuel gauge/hour meter to the blue wire on the key switch.
- 5.3.3. Check the continuity of the black ground wire at the fuel level sending unit.
- 5.3.4. Check the continuity of the black ground wires at the fuel gauge/hour meter.
6. If the readings are correct according to the position of the float, but give an incorrect reading on the fuel gauge/hour meter, test the fuel gauge/hour meter.

TEST PROCEDURE 20 – Fuel Gauge

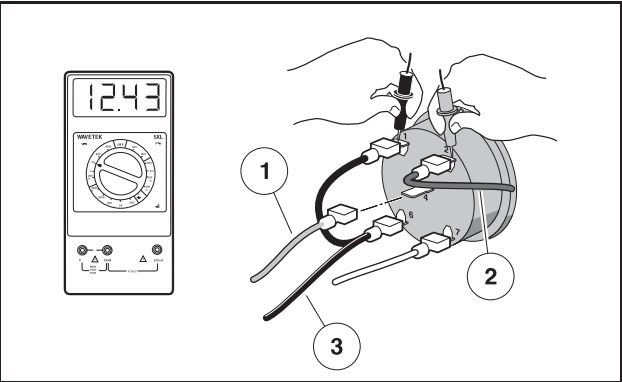
NOTE: This is a voltage test.



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Figure 19-17 Fuel Gauge/Hour Meter

1. Disable the vehicle.
2. Remove the instrument panel to gain access to the back of the fuel gauge/hour meter.
3. Place a sheet of insulating material between the front frame and the electrical connections on the rear of the instrument panel to prevent contact between the two.
4. Disconnect the orange wire (1) from the fuel gauge/hour meter (Figure 19-18, Page 19-29).

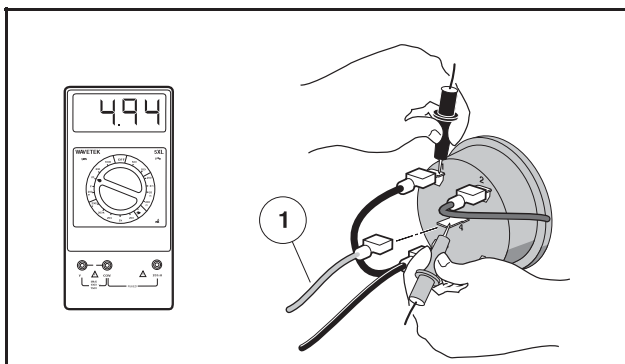


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Figure 19-18 Fuel Gauge Voltage Test - Terminal 2

5. Set a multimeter to 20 VDC.

6. Put the red (+) probe of the multimeter on the positive post of the battery.
7. Put the black (-) probe on the negative post of the battery. Record the voltage reading.
8. Put the red (+) probe on terminal 2 of the fuel gauge/hour meter with the blue wire (2) connected.
9. Put the black (-) probe on terminal 1 of the fuel gauge/hour meter with the black wire (3) connected.
10. Turn the key switch ON. The voltage reading should be the same as the battery voltage reading recorded earlier.
- 10.1. If not, check the continuity of the blue and black wires.
11. Make sure that the orange wire (1) is disconnected (**Figure 19-19, Page 19-30**).



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Figure 19-19 Fuel Gauge Voltage Test - Terminal 4

12. Put the black (-) probe on terminal 1 of the fuel gauge/hour meter.
13. Put the red (+) probe on terminal 4 of the fuel gauge/hour meter. The voltage reading should be approximately 4.94 volts.
- 13.1. If the reading is incorrect, replace the fuel gauge/hour meter.

TEST PROCEDURE 21 – Hour Meter

⚠ DANGER

- Do not operate vehicle in an enclosed area without proper ventilation. The engine produces carbon monoxide, which is an odorless, deadly poison.

NOTE: Keep the battery connected while performing this test procedure.

1. Disable the vehicle.
2. Make sure that the key switch OFF.
3. Check the hour meter display. It is powered by an internal battery and should always be on, even with the engine off and the key removed.
4. Start the engine and let it idle.
5. With engine idling, the "hour glass" icon should flash.
- 5.1. If not, check the voltage regulator. **See following NOTE.**

NOTE: The hour meter is designed to record actual engine running time and will not start adding increments until the engine is running.

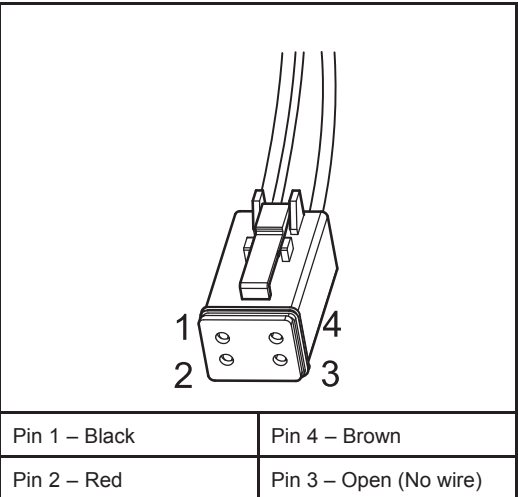
6. If the hour meter still does not function after the voltage regulator and all of the appropriate wires have been checked for continuity, replace the fuel gauge/hour meter.

TEST PROCEDURE 22 – 4-Pin Connector (to Visage)

See General Warnings on page 1-2.

NOTE: This is a voltage and continuity test.

The Connected Car Device 4-pin connector is used for Guardian/Visage and is labeled “V3 circuit” on the main wire harness.



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Figure 19-20 4-Pin Connector

1. If necessary, **See Testing Basics on page 19-7..**
2. Check for continuity between pin 1 (black wire) (**Figure 19-20, Page 19-31**) and pin 18 (black wire) of the black 18-pin connector on the ECU. It should indicate continuity. If not, check sonic welds no. 4, 10, and 14.
3. Probe pin 2 (red wire). It should show battery voltage with the key switch in the ON position. If not, check 2-amp fuse near ATM fuse holder. **See following NOTE.**

NOTE: The red wire only has battery voltage with the key switch in the ON position.

4. Probe pin 4 (brown wire). It should show approximately 11.8 volts supplied by pin B (red wire) of the engine harness. If not, check wiring and then ECU. **See following NOTE.**

NOTE: The brown wire only has voltage with the key switch in the ON position.

If pin 4 has no voltage, the ECU LIN (Local Interconnect bus) may have failed. The vehicle can be driven if it is not used with Guardian or Visage and will not show any symptoms. Otherwise, Guardian or Visage will disable the vehicle until communication is restored.

Pagination Page

⚠ DANGER

- See General Warnings on page 1-2.

⚠ WARNING

- See General Warnings on page 1-2.

BATTERY

⚠ DANGER

- Due to the danger of an exploding battery, wear a full face shield and rubber gloves when working on or near batteries.
- Battery – Explosive gases! Do not smoke. Keep sparks and flames away from the vehicle and service area. Ventilate when charging or operating vehicle in an enclosed area. Wear a full face shield and rubber gloves when working on or near batteries.
- Tools, wires, and metal objects can cause sparks when shorted across a battery.
- Follow all instructions carefully when working with batteries.
- Charge battery in a well-ventilated area only.
- Battery – Poison! Contains acid! Causes severe burns. Avoid contact with skin, eyes, or clothing. Antidotes:
 - External: Flush with water. Call a physician immediately.
 - Internal: Drink large quantities of milk or water followed with milk of magnesia or vegetable oil. Call a physician immediately.
 - Eyes: Flush with water for 15 minutes. Call a physician immediately.

⚠ WARNING

- Do not jump start a dead battery using another battery and jumper cables.

GENERAL INFORMATION

See preceding DANGER and WARNING statements.

Gasoline vehicles are equipped with a 12-volt, top post battery. When changing a 12-volt battery in any gasoline-powered vehicle, the same size battery with adequate amperage ratings should be used as a replacement.

A group 26 battery, with a 525 cold cranking amp rating and a reserve capacity of at least 85 minutes is recommended. The group 26 classification indicates battery size: 8 inches W x 6-3/4 inches D x 7 inches H (20.3 cm W x 17.2 cm D x 17.8 cm H). It is important to use the proper size to ensure that the battery clamp will fit correctly.

PREVENTIVE MAINTENANCE

1. To keep the battery in good operating condition, remove any corrosion immediately. Post connections should be clean and tight. Any frayed or worn wires should be replaced. After all cables have been connected and properly tightened to 41 lb·in (4.3 N·m), coat terminals with Battery Terminal Protector Spray to prevent future corrosion. **See preceding WARNINGS and following CAUTION.**

CAUTION

- If battery wire terminals are damaged or corroded, replace or clean them as necessary. Failure to do so may cause them to overheat during operation and could result in a fire, property damage, or personal injury.
2. The battery should be kept clean and dry to prevent self-discharge. Any dirt, grime or acid spillage should be removed. Wash the battery with a bristle brush using water and bicarbonate of soda (1 cup (237 mL) baking soda per 1 gallon (3.8 L) of water). Rinse with water. Do not allow solution to enter battery through the vent cap holes. **See Self-Discharge on page 20-2.**
 3. Check battery periodically to see that it is in a full state of charge. **See Charging the Battery on page 20-3.**
 4. Keep battery hold-down clamp tight. **See Vibration Damage on page 20-2.**

SELF-DISCHARGE

Dirt and battery acid can provide a path for a small current draw that slowly discharges the battery. To prevent self-discharge, the battery should always be kept clean.

Hot weather also has an effect on a battery's self-discharge rate. The higher the temperature, the quicker a battery will discharge. In hotter climates, therefore, the battery should be checked more often. When storing the battery, keep in a cool place. **See Battery Storage on page 20-4.**

VIBRATION DAMAGE

The battery hold-down clamp should always be tight enough to keep the battery from bouncing. Battery life may be severely shortened if the clamp is too loose. Excessive vibration shortens the life of the battery. It may also cause acid to leak out of the vent caps and corrosion to build up on surrounding metal parts. The acid that is lost reduces the capacity of the battery and cannot be replaced.

BATTERY REMOVAL

Also see **DANGER** at beginning of Battery topic.

1. Turn the key switch OFF and remove the key. Place the Forward/Neutral/Reverse handle in the NEUTRAL position. Chock the wheels.
2. Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. Remove the battery hold-down clamp from the battery.
4. Lift the battery from the vehicle. **See following WARNING.**

⚠ WARNING

- Keep the battery in an upright position to prevent electrolyte leakage. Tipping the battery beyond a 45° angle in any direction can allow a small amount of electrolyte to leak out of the vent hole. Do not exceed this 45° angle when lifting, carrying or installing battery. The battery acid could cause severe personal injury when accidentally coming in contact with the skin or eyes, and could damage clothing.

CHARGING THE BATTERY

Also see **DANGER** at beginning of Battery topic.

1. Charge the battery using an automotive type 12-volt battery charger. Follow all warnings and procedures supplied by the battery charger manufacturer.
2. Attach the positive (+) charger cable to the positive (+) battery post.
3. Attach the negative (–) charger cable to the negative (–) battery post.
4. The battery may be charged with a slow charge (3 to 10 amps) or a fast charge (20 to 30 amps). Charge until the battery voltage is greater than 12.4 volts. **See following WARNING.**

⚠ WARNING

- If the battery case feels hot (approximately 125 °F (52 °C) or more), emits gases, or fluid boils from vents, stop charging immediately. Failure to stop charging battery when any of these conditions are present could result in an explosion, personal injury and/or damage to the battery.
- Do not disconnect the charger DC leads from the battery when the charger is on. The resulting arcing between the DC leads and battery post could cause an explosion.
- If the charger must be stopped, disconnect the AC supply cord from the wall outlet before disconnecting the DC leads from the battery. Allow the battery to cool to room temperature and resume charging battery at a lower amp rate.

BATTERY INSTALLATION

Also see **DANGER** at beginning of Battery topic.

1. Place the battery into the vehicle with the battery posts facing the engine.
2. Secure the battery to the vehicle with the clamp and install bolt, washer and locknut and tighten to 41 lb·in (4.3 N·m). A loose battery clamp may allow the battery to become damaged from vibration or jarring.
3. Connect battery and spark plug wire. **See Connect the Battery - Gasoline Vehicles on page 1-4.**

BATTERY STORAGE

Also see **DANGER** at beginning of Battery topic.

1. Keep the battery clean and free of corrosion. **See Preventive Maintenance on page 20-2.**
2. The battery cables should be disconnected from the battery so the battery can be connected to the charger. The battery can be left in the vehicle. Disconnect the negative (–) cable first. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. Fully charge the battery prior to storage.
4. Store in a cool, dry area. The colder the area in which the battery is stored, the less the battery will self-discharge. A battery stored at 0 °F (-17.8 °C) will discharge very little over a four-month period. A battery stored at 80 °F (27 °C) will have to be recharged every few weeks.
5. Check the state of charge periodically. A battery that is discharged and left in a cold environment can freeze and crack. If the voltage drops below 12.4 volts, the battery should be recharged. **See following WARNING.**

⚠ WARNING

- If the battery is frozen or the container is bulged, discard battery. A frozen battery can explode.
6. The frequency of recharging required depends on the temperature of the storage area, but it is recommended that the battery be monitored for state of charge every month. Also, if the storage area is unheated in a cold climate and recharging is required, it is recommended that the area be heated to at least 60 °F (16 °C) prior to charging. The battery will not charge effectively in cold temperatures for the same reasons that it does not discharge as rapidly in cold temperatures.

CHARGING A DEAD BATTERY

Also see **DANGER** at beginning of Battery topic.

The vehicle is equipped with a starter/generator. The generator is not designed to charge a dead battery. If the vehicle battery has become discharged, it must be charged using a properly rated automotive type charger. **See following WARNING.**

⚠ WARNING

- Do not jump-start a dead battery using another battery and jumper cables.

GROUND CABLES

NOTE: Verify that all cables (fuel tank, engine, battery, starter/generator and voltage regulator) are connected securely.

STARTER/GENERATOR

STARTER/GENERATOR REMOVAL

1. Disconnect the battery and spark plug wire.
2. Set the Maintenance/Operate switch to MAINTENANCE.
3. Disconnect the wires from the A1, DF, and F2 terminals of the starter/generator (1).

4. Loosen the pivot nuts (2) and pivot bolts (3) (**Figure 20-1**).

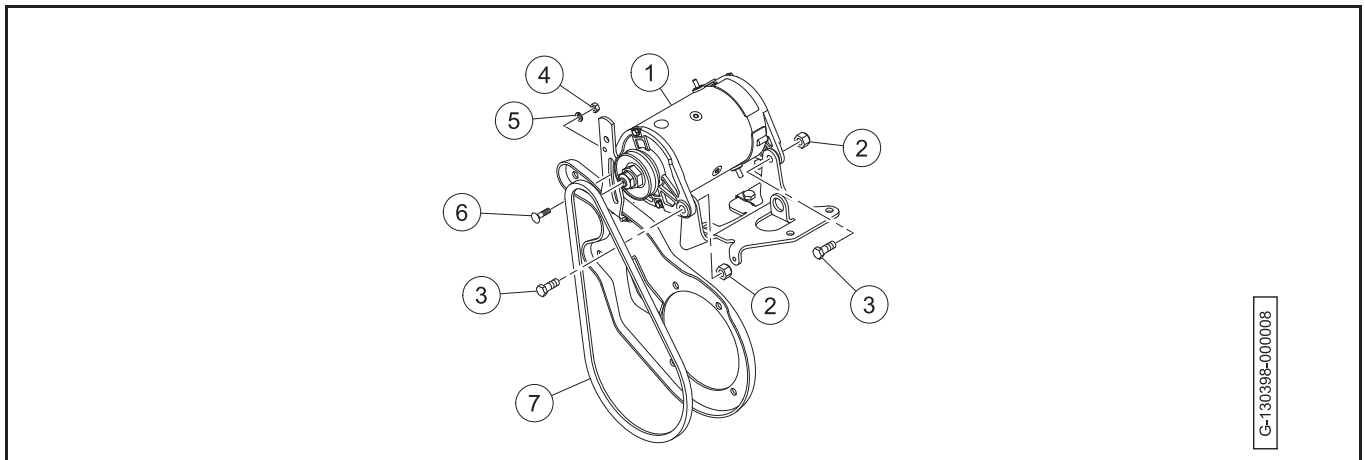


Figure 20-1 Starter/Generator Removal

5. Remove the adjustment nut (4), washer (5) and adjustment bolt (6).
6. Lower the starter/generator and remove the belt (7) from the starter/generator pulley.
7. Support the starter/generator so that when the pivot bolts are removed the starter/generator does not fall.
8. Remove the pivot nuts and bolts from the mounting bracket.
9. Remove the starter/generator.

DISASSEMBLY OF THE STARTER/GENERATOR TO SERVICE THE BRUSHES

1. Remove the jumper wire (1) and terminal hardware (2) (**Figure 20-2**).

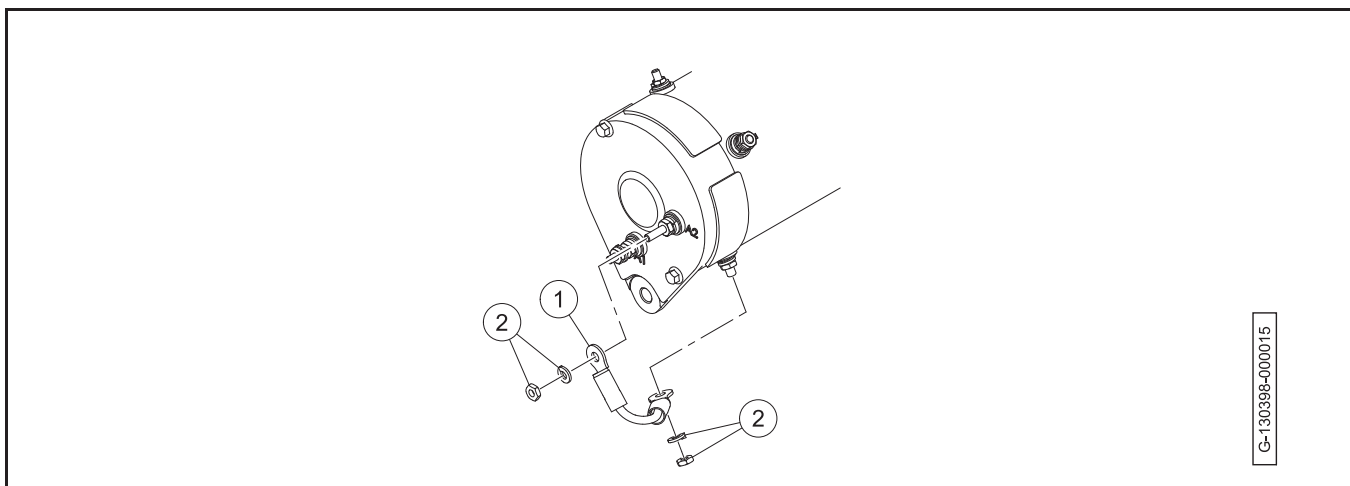


Figure 20-2 Jumper Wire Removal

2. Remove the bolts (1) and pull the commutator end cover (2) free of the field coil housing (3) (**Figure 20-3**).
See following NOTE.

NOTE: If the brushes are not removed, contact between the brushes and commutator as the commutator end cover is being removed or installed could damage the brushes. Lift the brush springs out of the notches in the brushes and pull the brushes back from the center of the commutator end cover. The springs will rest on the side of the brushes and help prevent them from sliding towards the center of the cover.

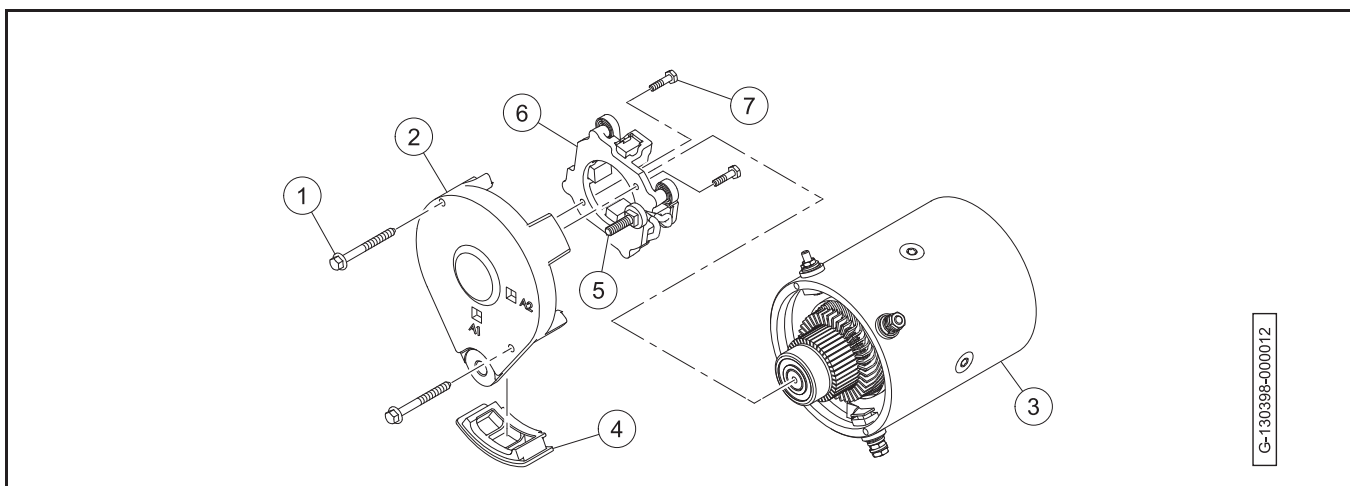


Figure 20-3 Starter/Generator Disassembly - Brushes

3. Remove the brush covers (4) and terminal hardware (5) from the commutator end cover.
4. Remove the screws (7) that attach the brush assembly (6) to the commutator end cover.

BRUSH AND BRUSH SPRING INSPECTION AND REPLACEMENT

1. Visually inspect brushes (1). Replace brushes that are cracked or severely chipped (**Figure 20-4**).

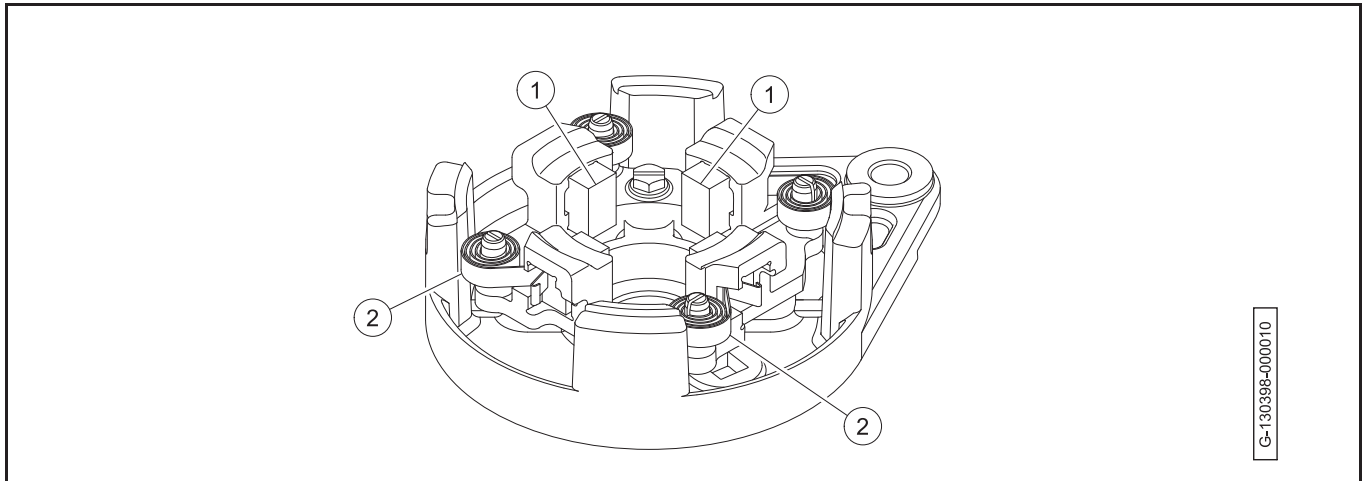


Figure 20-4 Brush and Brush Spring Inspection

2. Measure the length of each brush. Replace the brush set if a brush is less than 0.375 inch (9.5 mm).
3. Visually inspect springs (2). Replace all brush springs if any spring is discolored from heat (straw or bluish in color).
4. Install the brushes (1) into their holders and insert the brush springs (2).
5. Using a spring scale, test brush spring tension. If any spring has a tension less than 24 ozf (0.68 kgf), replace all four brush springs. **See following CAUTION.**

⚠ CAUTION

- When checking brush spring tension, do not push springs beyond the point they would normally be if there were new brushes installed. Exerting excessive force or pushing brush springs beyond their normal maximum extension point will damage springs.

DISASSEMBLY OF THE STARTER/GENERATOR TO SERVICE THE ARMATURE/COMMUTATOR

1. Remove the commutator end cover to prevent damage to the brushes and armature.
2. Remove the bolts (1) (**Figure 20-5, Page 20-8**).

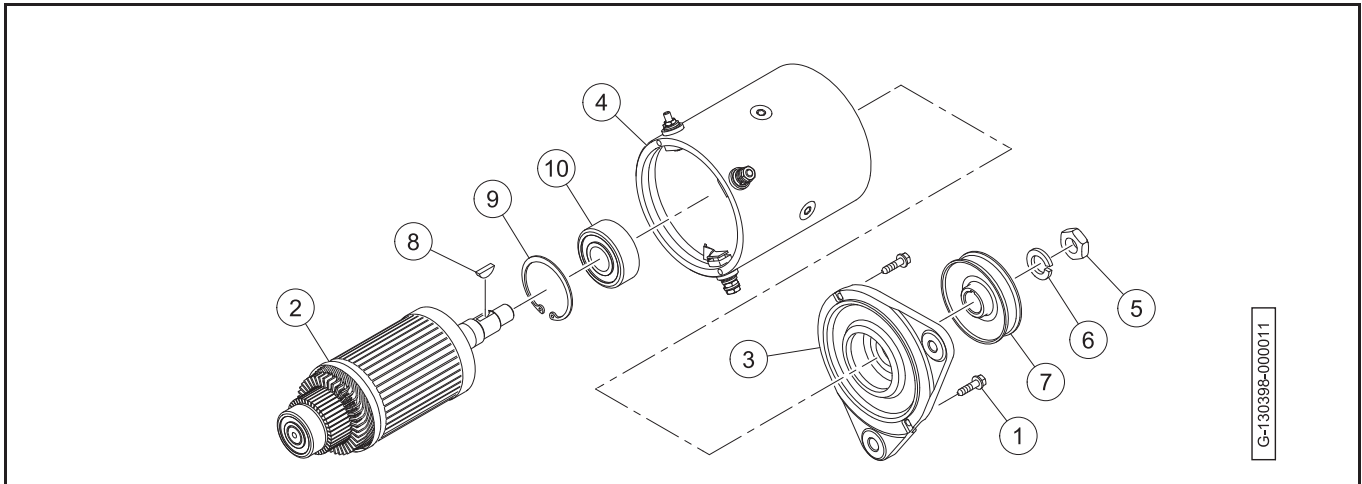


Figure 20-5 Output End Cover Disassembly, Armature and Housing

3. Remove the armature (2) and output end cover (3) from the field coil housing (4).
4. Remove the nut (5), lock washer (6), pulley (7), and woodruff key (8). **See following NOTE.**

NOTE: It may be necessary to use the wedge attachment tool to remove the pulley from the armature shaft.

5. Remove the internal retaining ring (9) to release the bearing (10) and armature from the output end cover.

BEARING CLEANING AND INSPECTION

1. Using a clean cloth, wipe the carbon dust from the two bearings. Inspect bearings by spinning them by hand and checking for both axial and radial play.
2. Replace the bearing if it is noisy, does not spin smoothly, or has excessive play.
3. Check the bearings and replace if rusted, worn, cracked, or if there is an abnormal color change in the metal of the bearing.
4. Bearings should be replaced if there is extensive wear or pitting on the balls or on the rolling surfaces.

NOTE: Do not remove the bearings unless they are to be replaced.

BEARING REMOVAL

1. Place the wedge attachment tool between the bearings (1) and the armature (2) (**Figure 20-6, Page 20-9**). **See following NOTE.**

NOTE: Make sure the wedge attachment tool is supporting the inner race of the bearing.

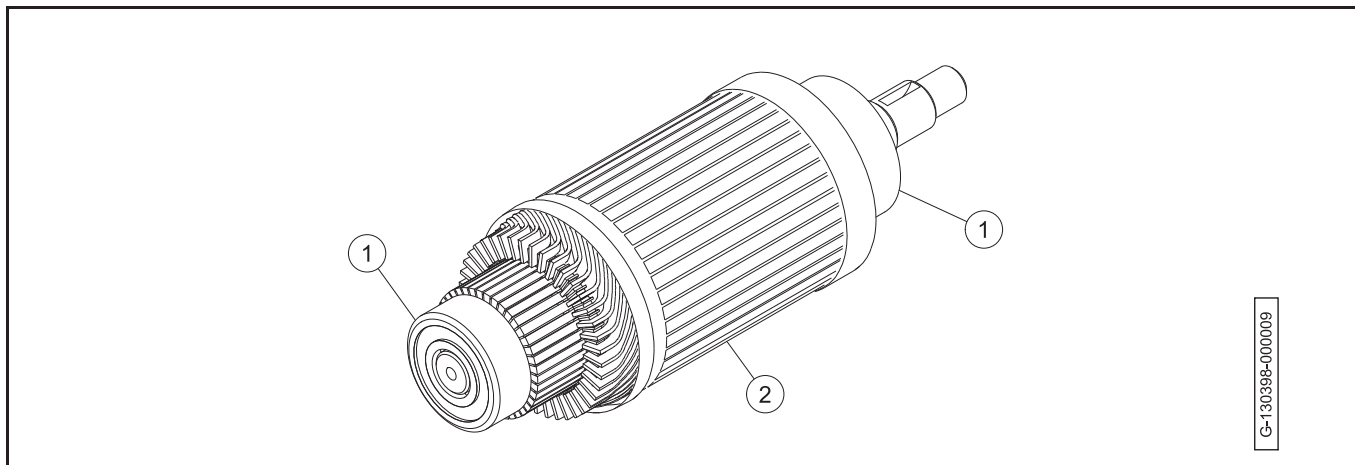


Figure 20-6 Bearing Removal

2. If a press is not available, secure a bearing puller to the wedge attachment tool and pull the bearings off of the end of the armature shaft. **See following NOTE.**

NOTE: Support the armature so that it will not drop when the bearing is removed.

FIELD COIL ASSEMBLY

Replace entire field coil housing assembly if coils, pole shoes or terminals are damaged..

VISUAL INSPECTION OF ARMATURE

Obvious defects can be seen by examining the armature. If an armature has frayed or charred insulation, broken wires or thrown solder, it is obvious without testing that it should be replaced. Faults seen during the visual inspection can aid in diagnosing the original cause of the failure. Items to look for are listed below.

- Burned, charred, or cracked insulation
- Improperly cured varnish
- Thrown solder
- Flared armature windings
- Worn, burned, or glazed commutator
- Loose or raised commutator bars
- Bruised or damaged armature core laminations
- Worn armature bearing or shaft
- Dirty or oily commutator

COMMUTATOR CLEANING AND INSPECTION

1. Visually inspect the commutator for worn, burned or glazed areas.
2. Check for loose or raised commutator bars.
3. Clean the carbon dust, dirt and oil from the commutator. Slight roughness of the commutator can be polished away with 400 grit (or finer) sandpaper. **See following CAUTION.**

⚠ CAUTION

- Do not use emery cloth on the commutator. Particles of emery are conductive and may short-circuit the commutator bars. Do not use oil or lubricants on the commutator or brushes.
4. Using a micrometer, measure the outside diameter at two points along the commutator. If the commutator outside diameter is less than 1.535 inches (39 mm), replace the armature and bearings (**Figure 20-7**). See following **NOTE**.

NOTE: Measure each position of the commutator in two places, 90 degrees apart.

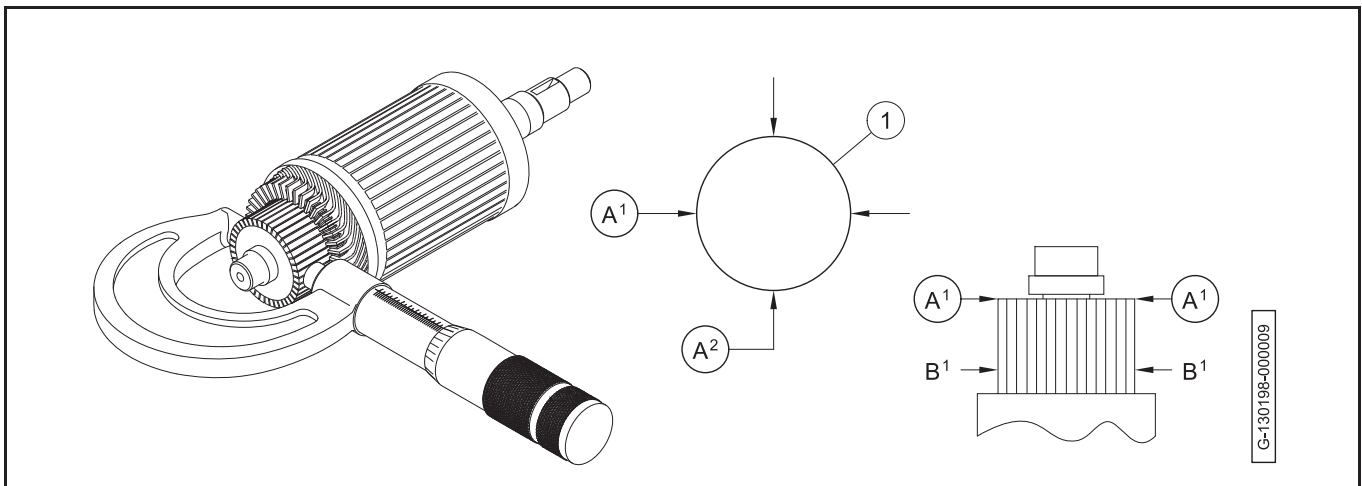


Figure 20-7 Inspect Commutator

ARMATURE GROUND TEST

⚠ CAUTION

- Do not submerge armature in solvent.

NOTE: Before testing, wipe the armature with a clean cloth and remove carbon dust and metal particles from between commutator bars.

Using a multimeter set on 200 ohms, place the positive (+) probe on the commutator bars (1) and the negative (–) probe on the armature shaft (2). The reading should be no continuity. If the reading is incorrect, replace the armature and the two bearings (**Figure 20-8**, **Page 20-11**).

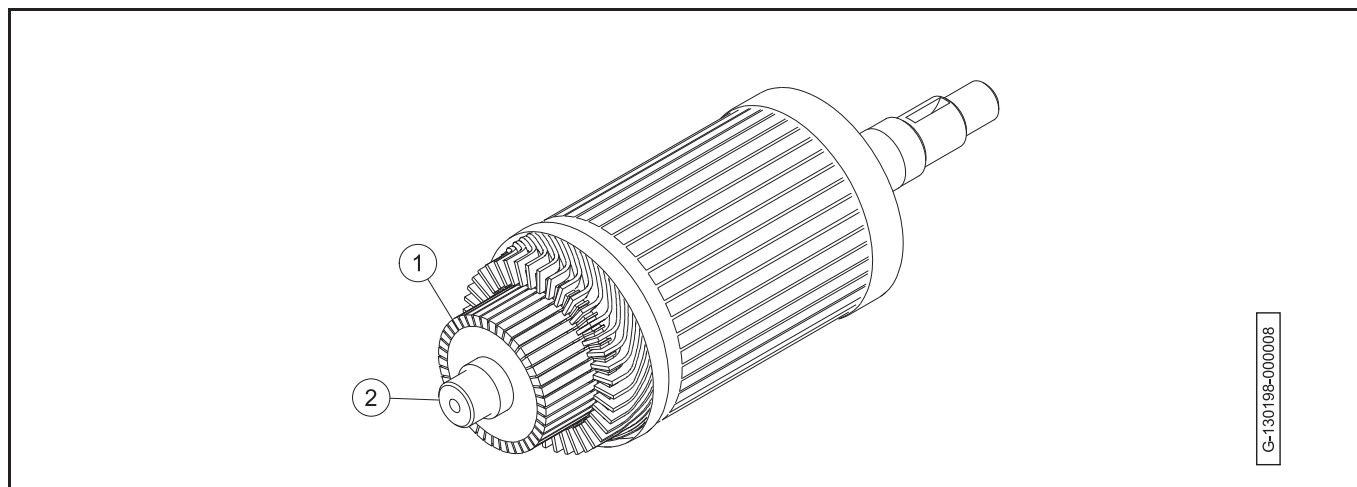


Figure 20-8 Armature Ground Test

VISUAL INSPECTION OF FIELD COILS

If the insulation on the field coils appears blackened or charred, the serviceability of the coils is questionable. Replace starter/generator if necessary.

Burned or scorched coil insulation indicates the starter/generator has overheated due to overloads or grounded or shorted coil windings. Be sure the insulators are tight in the housing.

STARTER/GENERATOR REWORK

Any rework must be performed by a qualified technician. Starter/generator service specifications are listed in the following table.

| ITEM | SERVICE LIMIT |
|---|------------------------|
| Commutator diameter (minimum) | 1.60 in. (41 mm) |
| Concentric with armature shaft within | 0.002 in. (0.051 mm) |
| Minimum commutator diameter for reslotting | 1.65 in. (42 mm) |
| Undercut (Commutator must have a minimum diameter of 1.65 in (42 mm) for reslotting): | 0.050 in. (1.3 mm) |
| Dielectric strength | 500 VAC for one minute |
| Armature insulation resistance | 0.2M (ohms) at 500 VDC |
| Starter field coil resistance | 0.006 to 0.01 ohms |
| Generator field coil resistance | 4.5 to 5.5 ohms |

STARTER/GENERATOR ASSEMBLY

1. Slide the internal retaining ring (9) on the output end of the armature (2) (**Figure 20-9**).

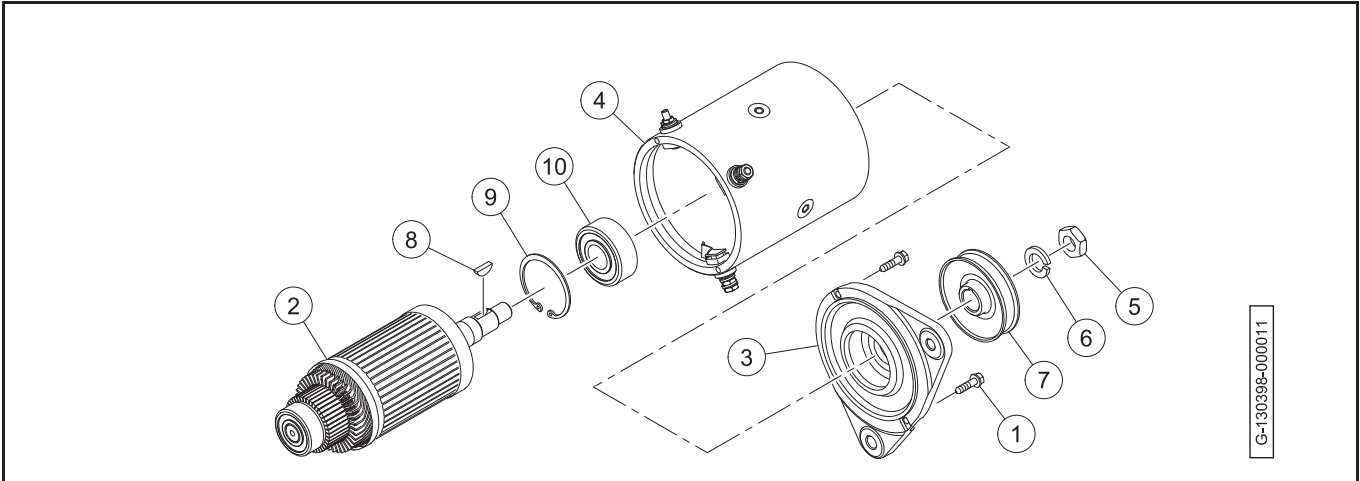


Figure 20-9 Output End Cover Assembly, Armature and Housing

2. Press a new ball bearing (10) onto the output end of the armature. **See following CAUTION.**

CAUTION

- To prevent damage to the retainer, use care while pressing new bearing onto the output end of the shaft.
 - Press against the inner race of the new bearing until it is fully seated.
3. Install the output end cover (3) on the armature. Secure the internal retaining ring.
 4. Slide the field coil housing (4) over the armature. Use the tapped mounting holes to align field coil housing to the output end cover. **See following NOTE.**

NOTE: The terminal insulators should be on the commutator end of the housing.

5. Install the bolts (1). Tighten the bolts from 49 to 66 lb·in (5.5 to 7.4 N·m).
6. Install the woodruff key (8) and pulley (7) onto the armature shaft.
7. Install the lock washer (6) and nut (5). Tighten the nut from 26 to 32.9 lb·ft (35.3 to 44.7 N·m).
8. Install the screws (7) that attach the brush assembly (6) and terminals (5) to the commutator end cover (2) (**Figure 20-10, Page 20-13**). Tighten the screws from 22 to 26 lb·in (2.4 to 2.9 N·m).

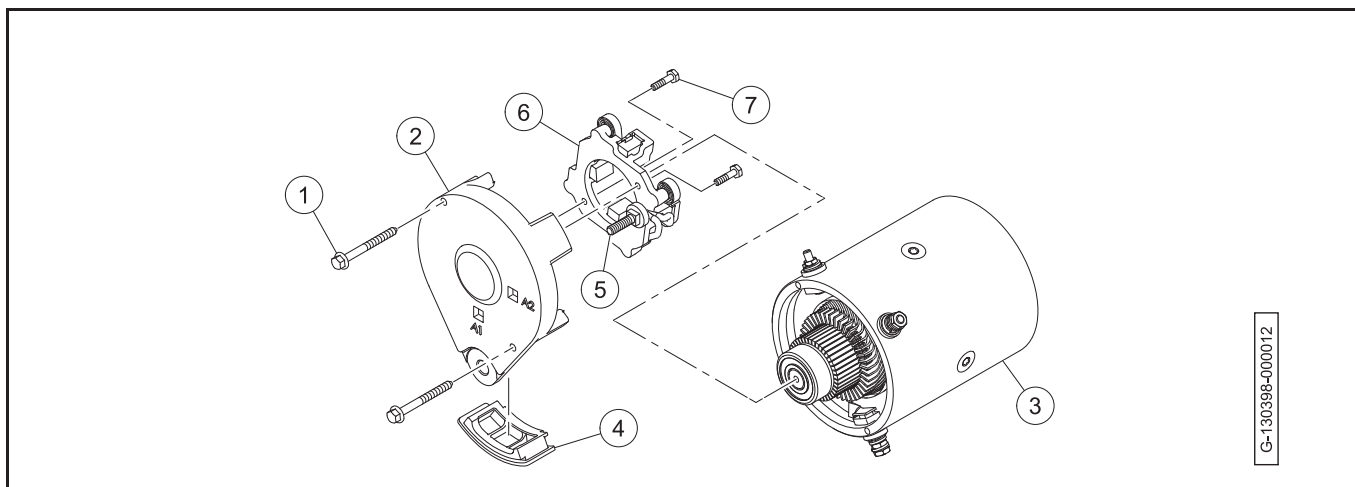


Figure 20-10 Starter/Generator Assembly - Brushes

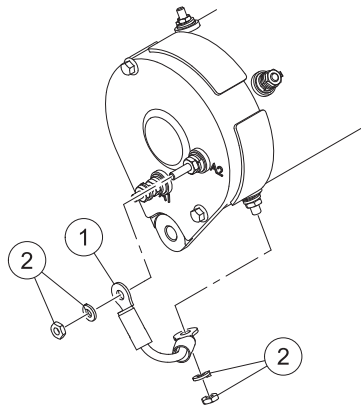
9. To prevent contact between the brushes and commutator as the commutator end cover is installed, and possible damage to the brushes:
 - 9.1. Lift the brush springs out of the notches in the brushes and pull the brushes back from the center of the commutator end cover.
 - 9.2. The springs will rest on the side of the brushes and help prevent them from sliding towards the center of the commutator end cover.
10. Install the commutator end cover onto the armature shaft. Use the tapped mounting holes to align housing to the field coil housing (3).
11. Install the bolts (1). Tighten the bolts from 49 to 66 lb·in (5.5 to 7.4 N·m).
12. Install the terminal hardware on the A1 and A2 terminals. Tighten the hardware from 40 to 50 lb·in (4.5 to 5.6 N·m).
13. Push the brushes down into the holders.
14. Place springs into the notches on the brushes. **See following NOTE.**

NOTE: Check the brush wires to make sure they do not interfere with the springs.

15. Install the brush covers (4). **See following NOTE.**

NOTE: The brush cover with the drain hole is installed next to the A2 terminal.

16. Install the terminal jumper wire (1) on the A2 and F1 terminals on the starter/generator (**Figure 20-11, Page 20-14**).



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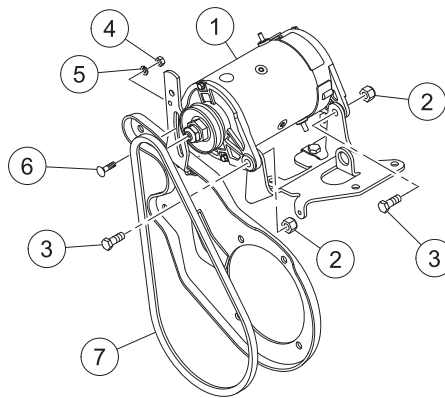
Figure 20-11 A2 to F1 Terminal Jumper Wire

17. Install the terminal hardware (2). Tighten the hardware from 39.8 to 49.5 lb·in (4.5 to 5.6 N·m). **See following NOTE.**

NOTE: Secure bottom nut of terminal with wrench before tightening top nut.

STARTER/GENERATOR INSTALLATION

1. Position the starter/generator (1) over the mounting bracket (**Figure 20-12**).



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Figure 20-12 Starter/Generator Installation

2. Install the pivot bolts (3) and pivot nuts (2). Tighten the pivot nuts with your hand.
3. Install the adjustment bolt (6), lock washer (5), and nut (4). Tighten the hardware hand-tight.
4. Install the starter/generator belt (7).
5. Adjust the belt tension. See Belt Tension Adjustment for EFI Engines.
6. Connect the yellow wire from the voltage regulator to the DF terminal on the starter/generator (**Figure 20-13, Page 20-15**).

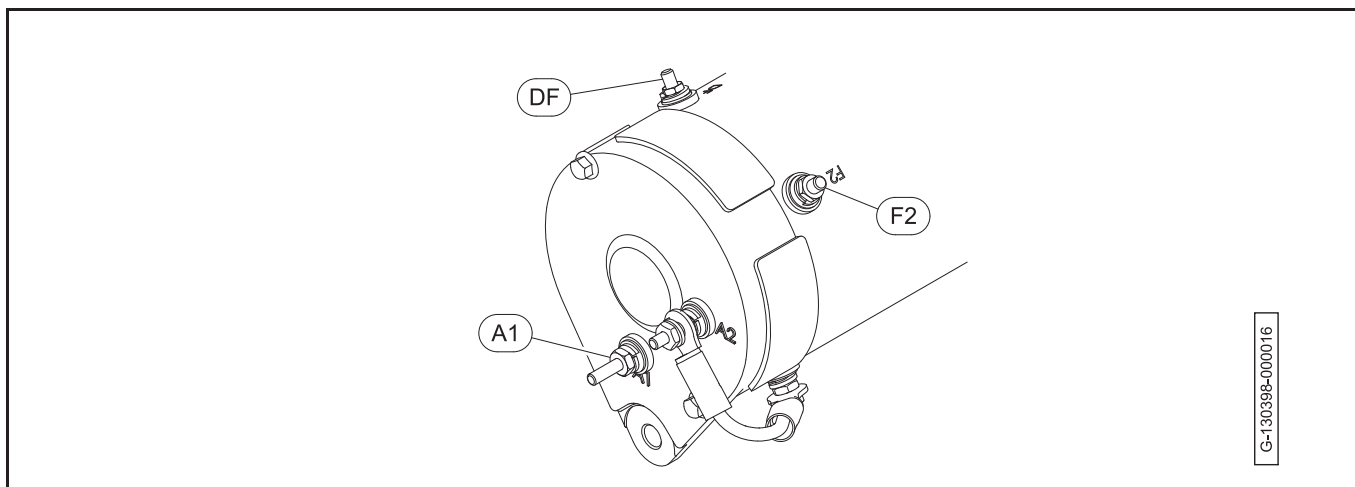


Figure 20-13 Wire Installation

7. Install a flat washer, lock washer, and nut on the DF terminal. Tighten the nut from 15 to 19.4 in·lb (1.7 to 2.2 N·m).
8. Install the white wire from the solenoid to the F2 terminal on the starter/generator.
9. Install the black wire from the frame to the A1 terminal on the starter/generator.
10. Install a flat washer, lock washer and nut on each terminal, and tighten the nuts from 40 to 50 lb·in (4.5 to 5.6 N·m).
11. Connect the battery and spark plug wire.

BELT TENSION INSPECTION FOR EFI ENGINES

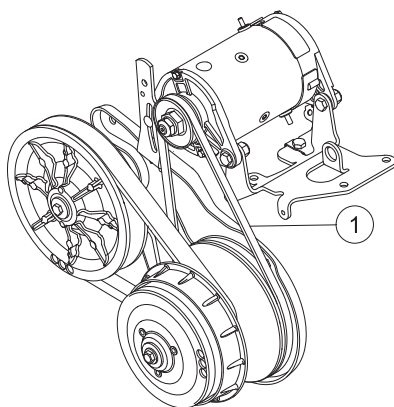
NOTE: To prevent belt slipping while starting an EFI engine, follow procedure outlined below which is best performed by two people to expedite the process, but can be performed by a single individual if required.

The amount a starter/generator belt is tensioned varies between a used and new belt.

EFI engines have higher starting torque demands that require consistent belt tension to prevent slipping. Belt tension should be checked periodically.

Existing Belts Only

1. Disconnect the battery and spark plug wire.
2. Mark a location on belt (1) to repeat tension measurement each time. Use a paint pen or permanent marker of light color (**Figure 20-14, Page 20-16**).



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Figure 20-14 Belt Tension

3. Install a Universal Belt Tension Gauge midway between the drive clutch and driven clutch.
4. Measure the belt tension. Correct belt tension for a used starter/generator belt is 75 to 85 lbf (334 to 378 N).
 - 4.1. If the belt tension is within the accepted range, no further action is needed. Connect the battery and spark plug wire.
 - 4.2. If the belt tension is not within the accepted range, adjust the belt tension. See Belt Tension Adjustment For EFI Engines.

BELT TENSION ADJUSTMENT FOR EFI ENGINES

NOTE: To prevent belt slipping while starting an EFI engine, follow procedure outlined below which is best performed by two people to expedite the process, but can be performed by a single individual if required.

The amount a starter/generator belt is tensioned varies between a used and new belt.

EFI engines have higher starting torque demands that require consistent belt tension to prevent slipping. Belt tension should be checked periodically.

1. Disable the vehicle.
2. Disconnect the battery and spark plug wire.
3. Mark a location on belt (1) to repeat tension measurement each time. Use a paint pen or permanent marker of light color (**Figure 20-15, Page 20-17**).

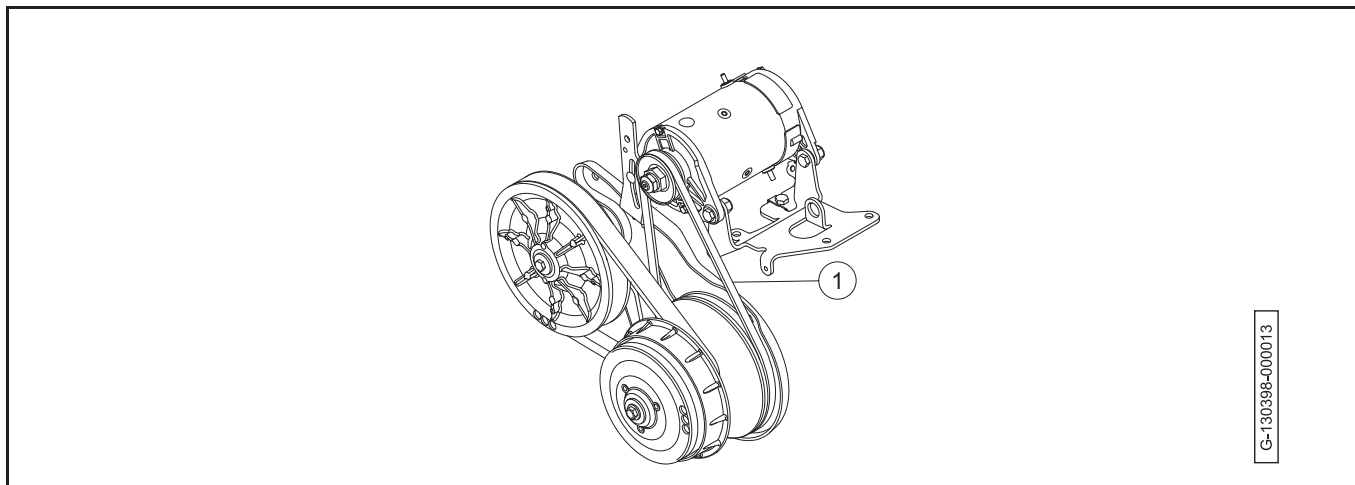


Figure 20-15 Belt Tension

4. Install a Universal Belt Tension Gauge midway between the drive clutch and driven clutch.
5. Loosen, do not remove, the adjustment nut (1) and pivot nuts (2) (**Figure 20-16**).

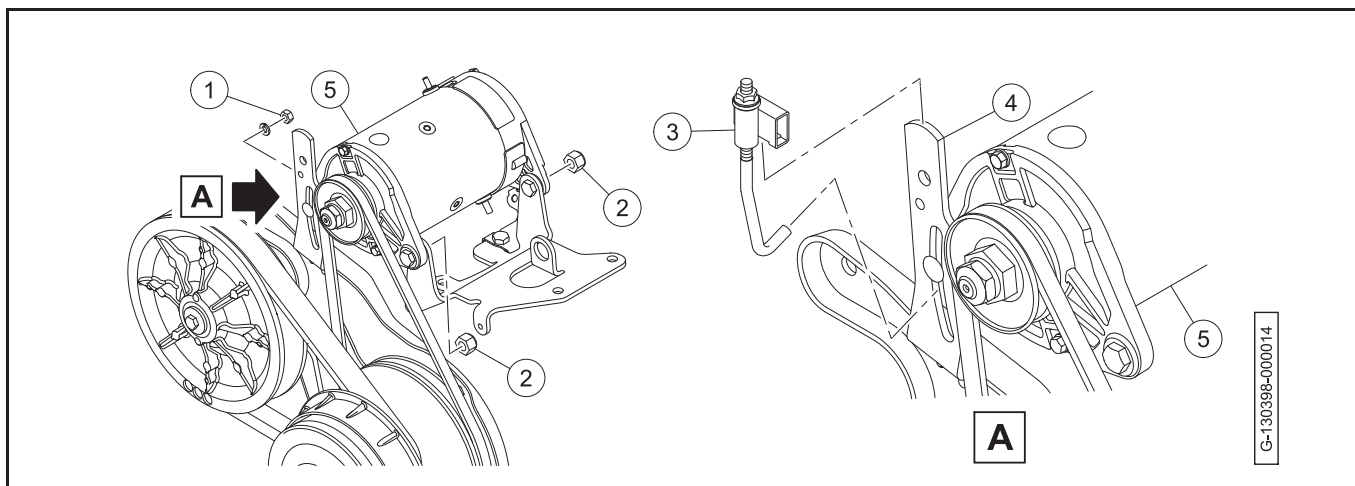


Figure 20-16 Belt Tension Adjustment

6. Install the belt tension tool (3) on the slotted adjustment bracket (4).
- 6.1. Carefully insert pry bar between starter/generator (5) and slotted adjustment bracket.

NOTE: In some cases, the threaded J-bolt of the belt tension tool does not have enough length to consistently fit under the starter/generator mounting ear. Fit can be greatly improved by modifying the tension tool. See *Belt Tension Tool Modification*.

- 6.2. Lift the starter/generator up until the tension tool can be installed into the slotted adjustment bracket.
- 6.3. Remove the pry bar.
7. Tension the belt.
- 7.1. Tighten the nut on belt tension tool 1/2 turn and check belt tension with the gauge.

NOTE: To prevent errors in measurement caused by residual tension, loosen then reapply, the Universal Belt Tension gauge between measurements.

- 7.2. Continue to tighten in 1/2 turn increments until proper belt tension is achieved.
 - Proper tension for a **used** starter/generator belt is 75 to 85 lbf (334 to 378 N).
 - Proper tension for a **new** starter/generator belt is 120 to 130 lbf (534 to 578 N).
8. Seat the belt.
- 8.1. Remove all other tools.
- 8.2. The belt tension tool can be temporarily left in place.
- 8.3. Only connect the battery. **DO NOT CONNECT SPARK PLUG WIRE. See following WARNING.**

⚠ WARNING

- **Remove pry bar before starting engine.**
- **Ensure clearance between F2 terminal and starter/generator bracket before starting engine.**

- 8.4. Operate the engine a minimum of 5 seconds and a maximum of 15 seconds to fully seat the belt into the pulleys and help eliminate any slack.
9. Repeat step 7.
10. Maintain tension and tighten the adjustment nut from 15 to 18 ft·lb (20 to 24.5 N·m). Tighten the pivot nuts from 20 to 25 ft·lb (27 to 34 N·m).
11. Remove the belt tension tool.
12. Confirm proper belt tension with a final measurement.
13. Connect the spark plug wire.

BELT TENSION TOOL MODIFICATION

1. Remove the nut (1), washer (2), and spacer (3) from the J-bolt (4) (**Figure 20-17**).

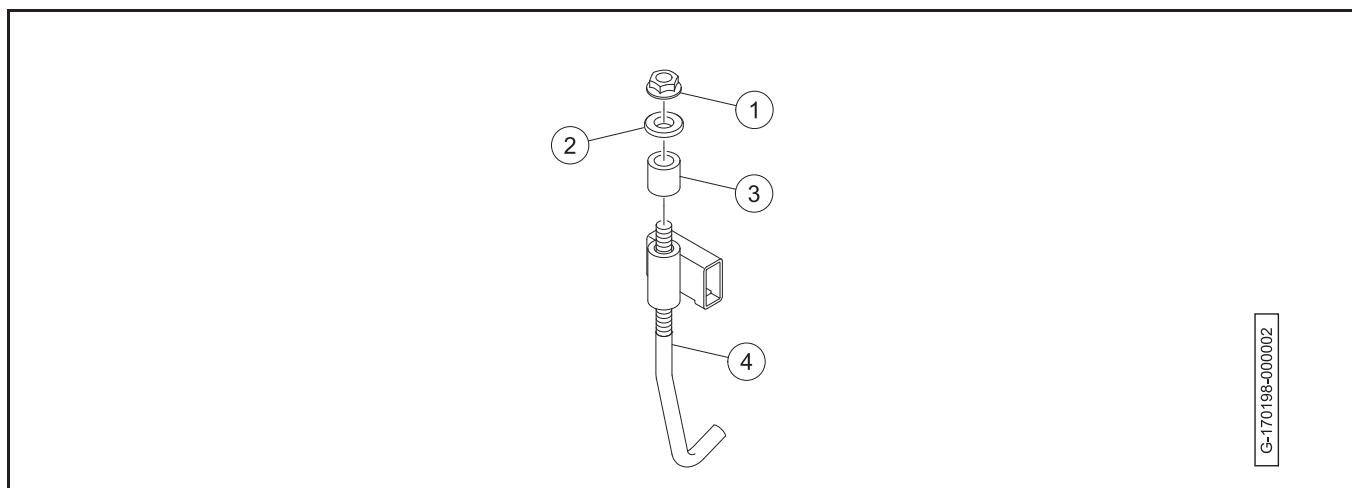


Figure 20-17 Belt Tension Tool Modification

2. Install the washer and nut onto the J-bolt.

SOLENOID

See General Warnings on page 1-2.

SOLENOID REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the nuts (1) from each post (Figure 20-18, Page 20-19).

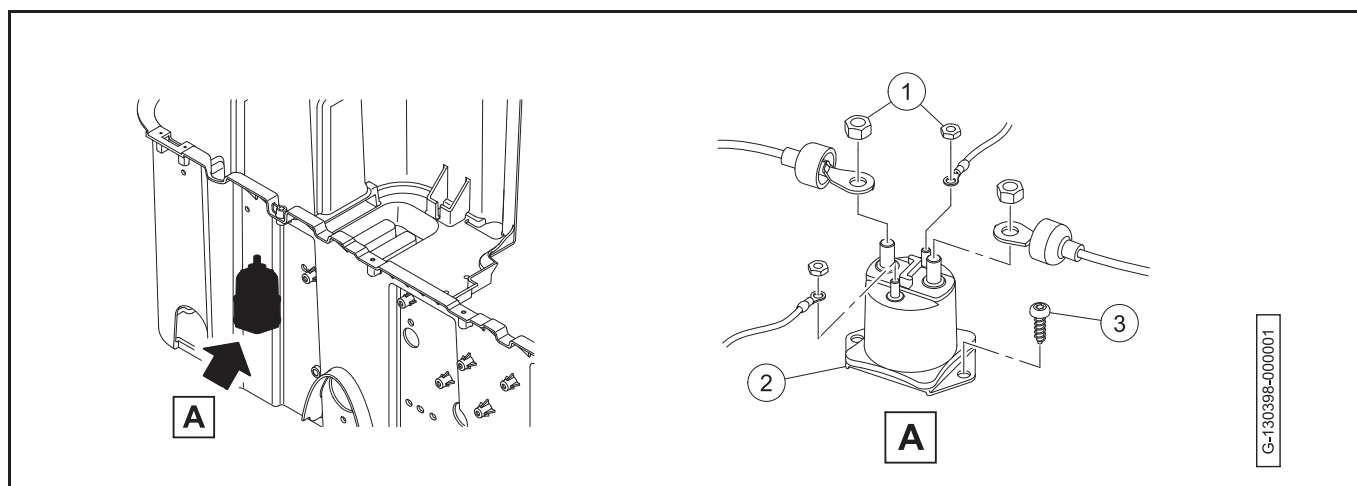


Figure 20-18 Solenoid Removal

3. Disconnect all the wires from the solenoid (2).
4. Remove the two screws (3).
5. Remove the solenoid.

SOLENOID INSTALLATION

1. Install the solenoid (1) in the vehicle (Figure 20-19, Page 20-19).

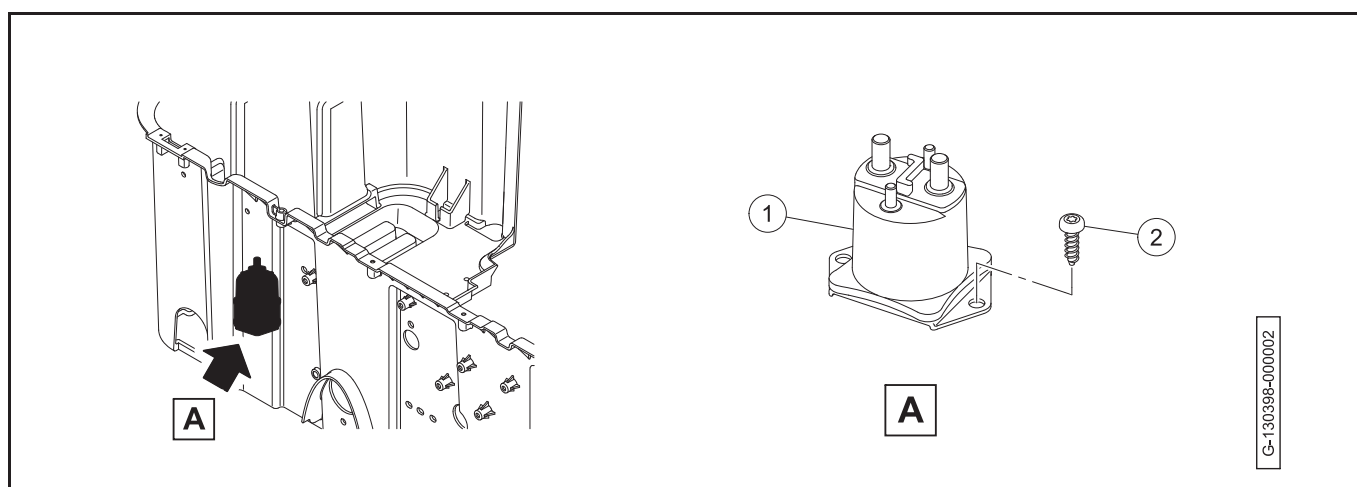


Figure 20-19 Solenoid Installation

2. Install the two screws (2). Tighten the screws to 31 lb·in (3.5 N·m).
3. Connect the white wire to the large post (3) on the solenoid (**Figure 20-20, Page 20-20**).

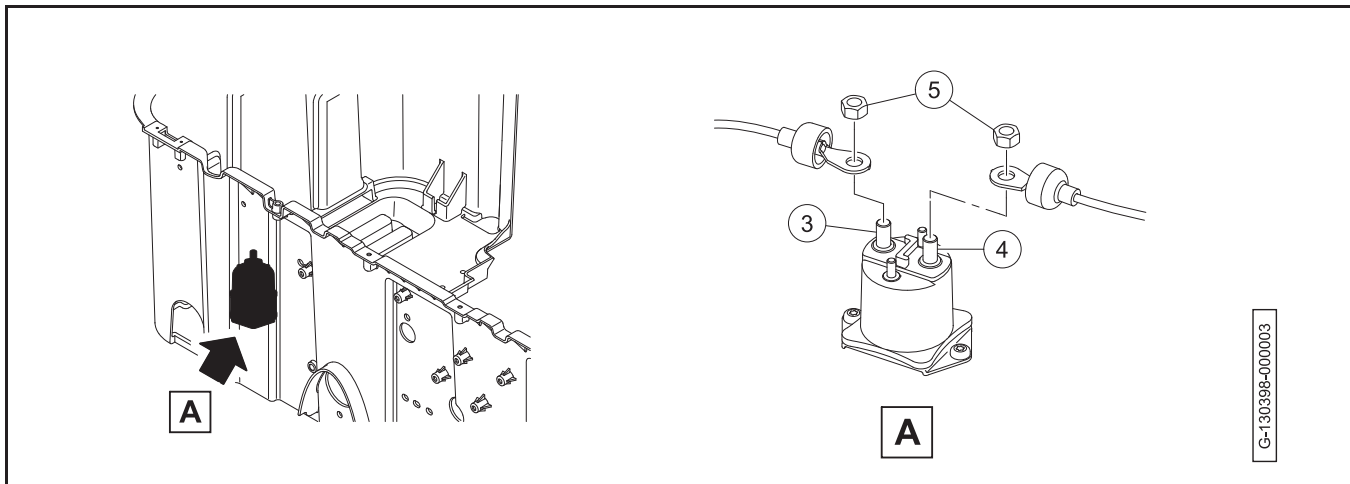


Figure 20-20 Solenoid Large Posts

4. Connect the red wire to the large post (4) on the solenoid.
5. Install the nuts (5). Tighten the nuts to 59 lb·in (6.7 N·m).
6. Connect the blue wire to the small post (6) on the solenoid (**Figure 20-21, Page 20-20**).

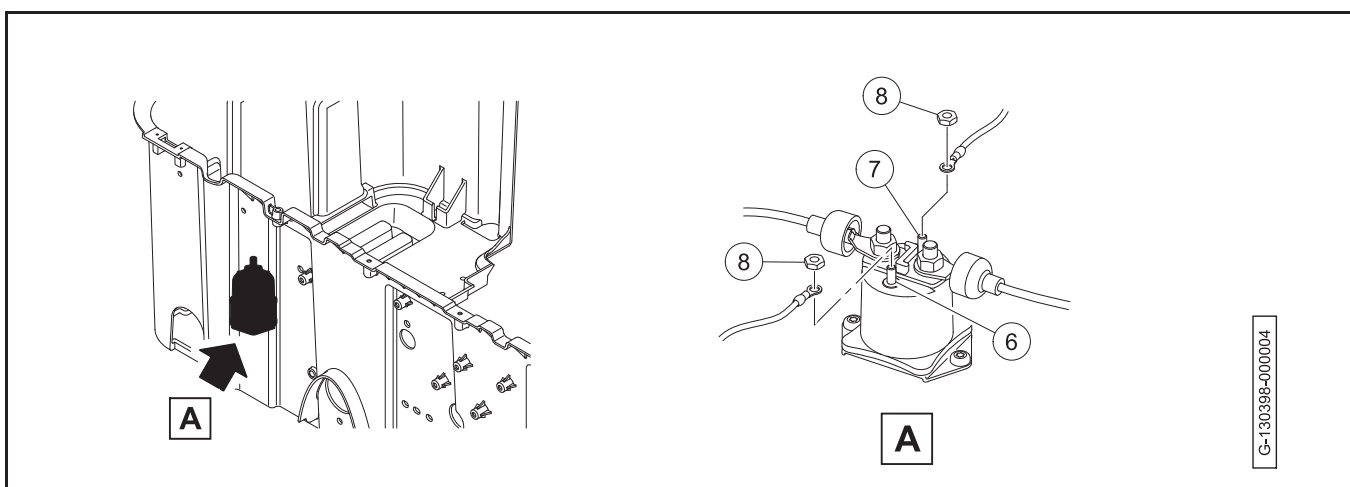


Figure 20-21 Solenoid Small Posts

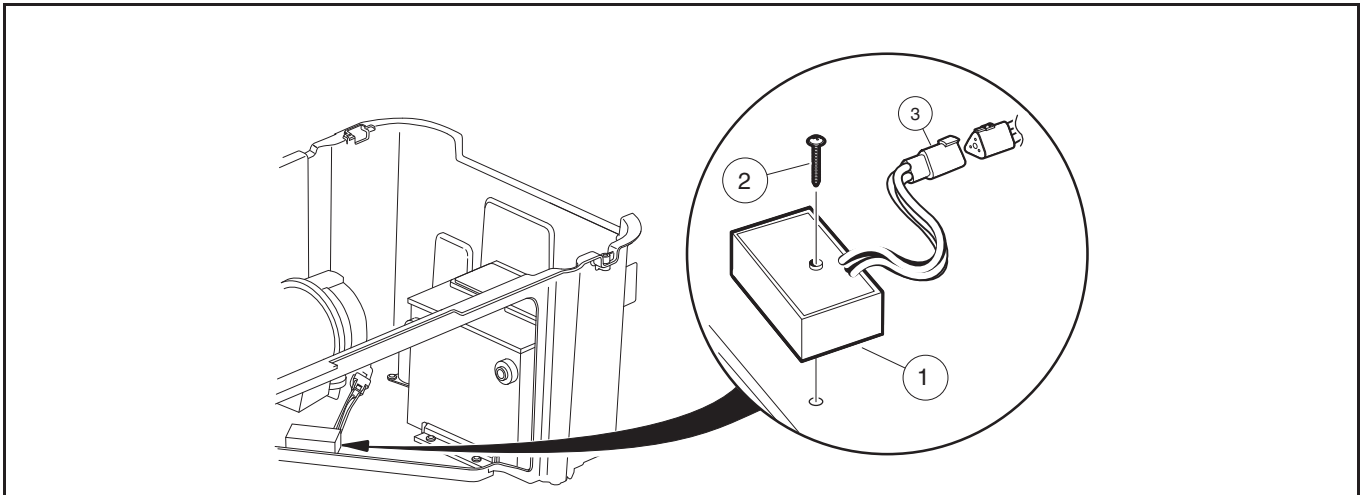
7. Connect the orange wire to the small post (7) on the solenoid.
8. Install the nuts (8). Tighten the nuts to 22 lb·in (2.5 N·m).
9. Connect the battery and spark plug wire.

VOLTAGE REGULATOR

See General Warnings on page 1-2.

VOLTAGE REGULATOR REMOVAL

1. Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Disconnect the voltage regulator connector (3) from the wire harness (**Figure 20-22, Page 20-21**).
3. Remove the voltage regulator mounting screw (2) and remove the voltage regulator (1).



2432

Figure 20-22 Voltage Regulator

VOLTAGE REGULATOR INSTALLATION

1. Position the voltage regulator (1) and install the mounting screw (2) (**Figure 20-22, Page 20-21**). Tighten screw to 23 lb·in (2.6 N·m).
2. Connect the voltage regulator three-pin connector (3) to the wire harness.
3. Connect battery and spark plug wire.
See Connect the Battery - Gasoline Vehicles on page 1-4.
4. Set the Forward/Neutral/Reverse control (FNR) to N.
5. Set the maintenance/operate switch to MAINTENANCE.
6. Start the engine and check regulator for proper functioning as described in the voltage regulator test procedure.
See Test Procedure 12 – Voltage Regulator on page 19-20.

ENGINE CONTROL UNIT (ECU)

The ECU is located in the engine compartment.

ENGINE CONTROL UNIT REMOVAL

1. Disconnect battery.
2. Remove ECU mounting plate bolts.
3. Disconnect gray and black wire connectors.

ENGINE CONTROL UNIT INSTALLATION

⚠ WARNING

- To prevent damage to the ECU, never mix the black and gray connectors that attach to it. The black connector is tethered to the ECU mounting plate to help prevent accidentally installing it in the gray port.

1. Mount ECU to plate with bolts and tighten to 60 lb·in (6.8 N·m).
2. Install gray connector to the gray port on the ECU. **See preceding WARNING.**
3. Install black connector to the black port on the ECU.
4. Connect the battery.

FUEL LEVEL SENDING UNIT

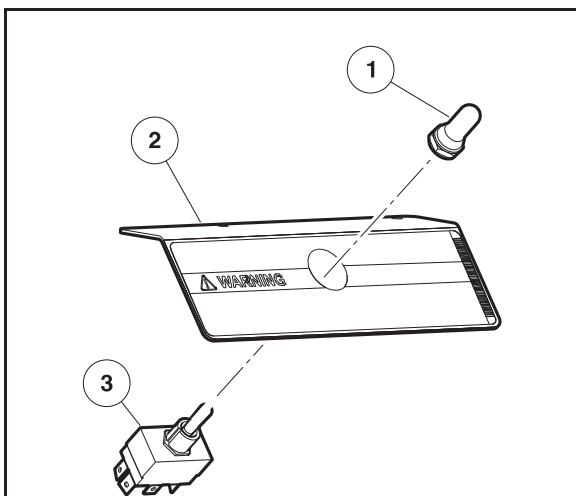
See General Warnings on page 1-2.

The fuel level sending unit is an integral part of the fuel pump module and is not replaceable. Thoroughly test the fuel level sending unit before replacing the fuel pump module.

MAINTENANCE/OPERATE SWITCH

MAINTENANCE/OPERATE SWITCH REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the boot/hex nut (1) (Figure 20-23).



000755-004

Figure 20-23 Maintenance/Operate Switch

3. Remove the Maintenance/Operate switch (2) from bracket (3).

4. Disconnect the wires and remove Maintenance/Operate switch.

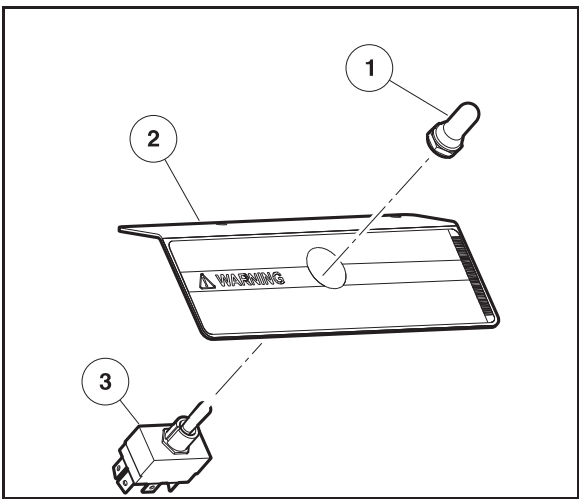
MAINTENANCE/OPERATE SWITCH INSTALLATION

1. Connect the wires to the Maintenance/Operate switch.

Pedal-Start

| Terminal | Wire Color |
|----------|----------------|
| T1 | Black / Pink |
| T2 | Black |
| T3 | Black / Yellow |

2. Make sure that the groove switch is aligned with tang on bracket (3) and install the Maintenance/Operate switch (2) (Figure 20-24, Page 20-23).



000755-004

Figure 20-24 Maintenance/Operate Switch

3. Install the boot/hex nut (1). Tighten the boot/hex nut to 16 in·lb (1.8 N·m).
4. Connect the battery.

ACCELERATOR PEDAL LIMIT SWITCH

See General Warnings on page 1-2.

The accelerator pedal limit switch is housed inside the throttle position sensor. The throttle position sensor itself is not intended to be replaced. If sensor is determined to need replacing through test procedures found in this manual, the accelerator pedal assembly must be replaced.

KILL LIMIT SWITCH

See General Warnings on page 1-2.

The kill limit switch is housed inside the throttle position sensor. The throttle position sensor itself is not intended to be replaced. If sensor is determined to need replacing through test procedures found in this manual, the accelerator pedal assembly must be replaced.

MULTI-PURPOSE BUZZER LIMIT SWITCH

See General Warnings on page 1-2.

The multi-purpose buzzer limit switch is located on the back of the Forward/Neutral/Reverse control (FNR).

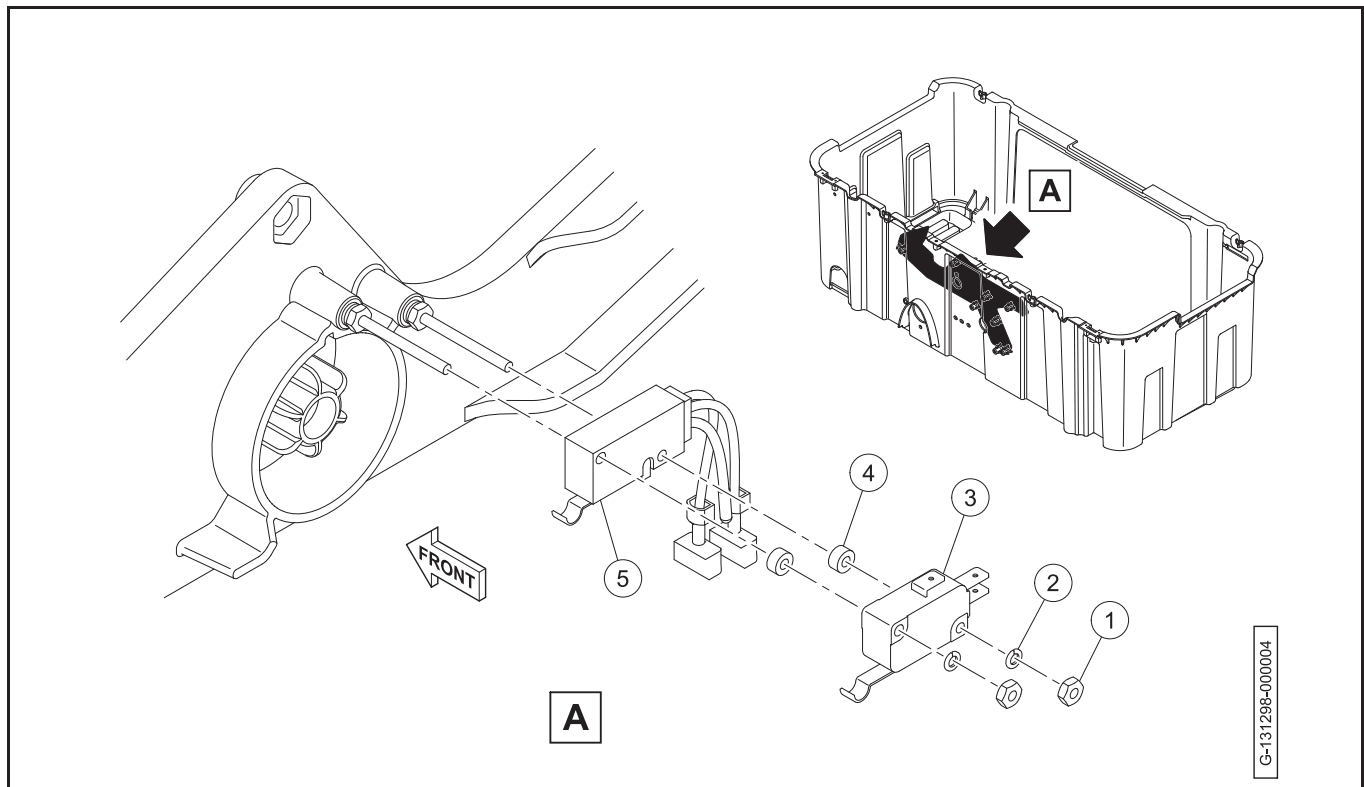


Figure 20-25 Multi-purpose Buzzer Limit Switch

MULTI-PURPOSE BUZZER LIMIT SWITCH REMOVAL

1. Disconnect the battery and spark plug wire.
2. Disconnect the multi-purpose buzzer limit switch wires from the main harness.
3. Remove the nuts (1) and washers (2) (**Figure 20-25, Page 20-24**).
4. Remove the neutral lockout limit switch (3) and washers (4).
5. Remove the multi-purpose buzzer limit switch (5).

MULTI-PURPOSE BUZZER LIMIT SWITCH INSTALLATION

1. Install the multi-purpose buzzer limit switch (5) on the two bolts (Figure 20-25, Page 20-24).
2. Install washers (4) and neutral lockout limit switch (3).

CAUTION

- Do not overtighten the nuts. If the nuts are over tightened, the limit switches could be damaged.

3. Install the washers (2) and nuts (1). Tighten the nuts to 4 in·lb (0.45 N·m).
4. Set the Forward/Neutral/Reverse control (FNR) to R.
5. Make sure that both limit switches actuate.
6. Connect the blue multi-purpose buzzer limit switch wire to the main harness red wire.
7. Connect the black multi-purpose buzzer limit switch wire to the main harness orange wire.

NOTE: The red multi-purpose buzzer limit switch wire is not connected.

8. Connect the battery and spark plug wire.
9. Set the FNR to R. Make sure that the multi-purpose buzzer operates.

NEUTRAL LOCKOUT LIMIT SWITCH

See General Warnings on page 1-2.

The neutral lockout limit switch is located on the back of the Forward/Neutral/Reverse control (FNR).

NEUTRAL LOCKOUT LIMIT SWITCH REMOVAL

- 1.
2. Disconnect the battery and spark plug wire.
3. Disconnect the wires from the neutral lockout limit switch (1) (Figure 20-26, Page 20-25).

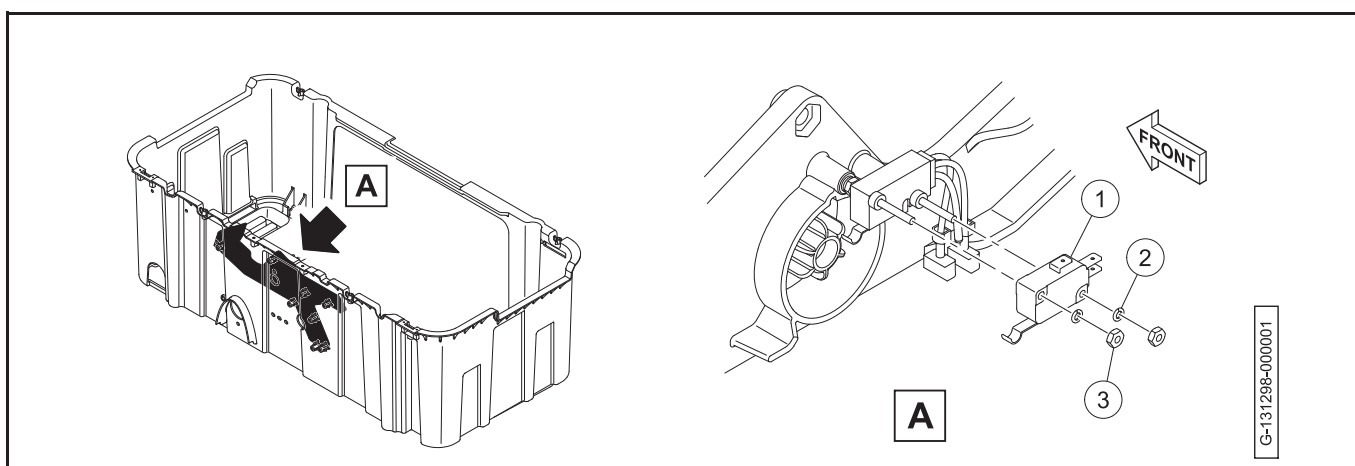


Figure 20-26 Neutral Lockout Limit Switch Removal

4. Remove the nuts (2) and washers (3).
5. Remove the neutral lockout limit switch.

NEUTRAL LOCKOUT LIMIT SWITCH INSTALLATION

1. Install the neutral lockout limit switch (1) on the bolts (Figure 20-27, Page 20-26).

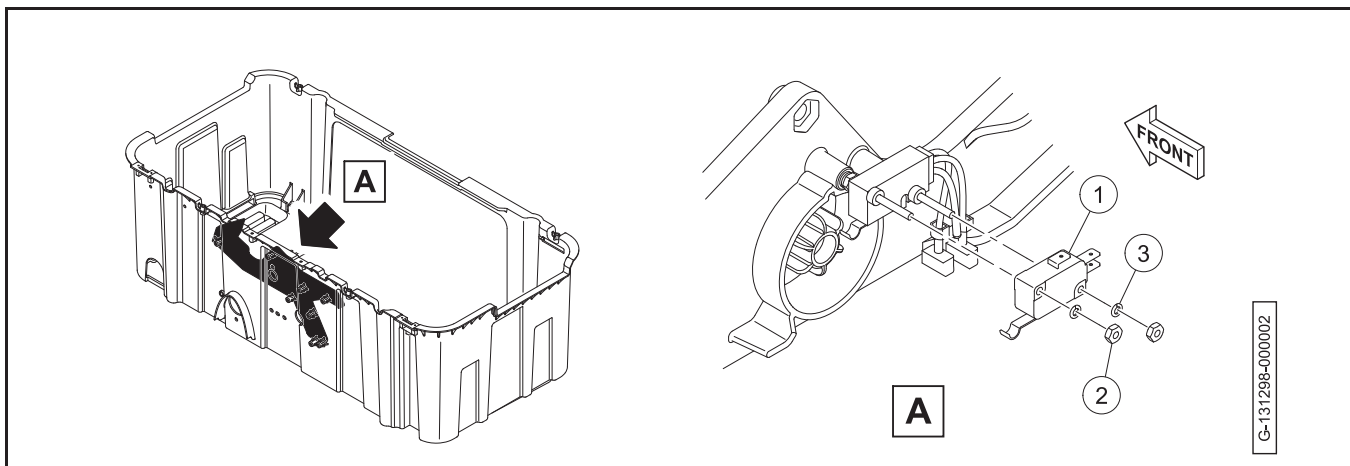


Figure 20-27 Neutral Lockout Limit Switch Installation

CAUTION

- Do not overtighten the nuts. If the nuts are over tightened, the limit switches could be damaged.

2. Install the washers (2) and nuts (3). Tighten the nuts to 4 in·lb (0.45 N·m).
3. Set the Forward/Neutral/Reverse control (FNR) to R.
4. Make sure that both limit switches actuate.
5. Connect the black/yellow wire to the COM1 terminal (4) (Figure 20-28, Page 20-26).

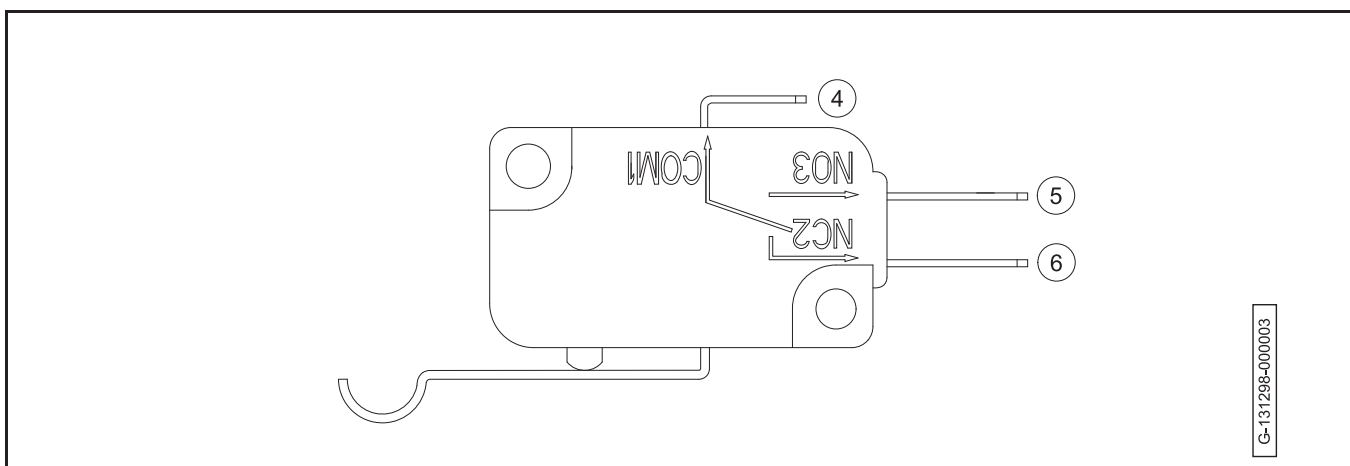


Figure 20-28 Neutral Lockout Limit Switch Terminals

6. Connect the green wire to the NO3 terminal (5).
7. Connect the white/black wire to the NC2 terminal (6).

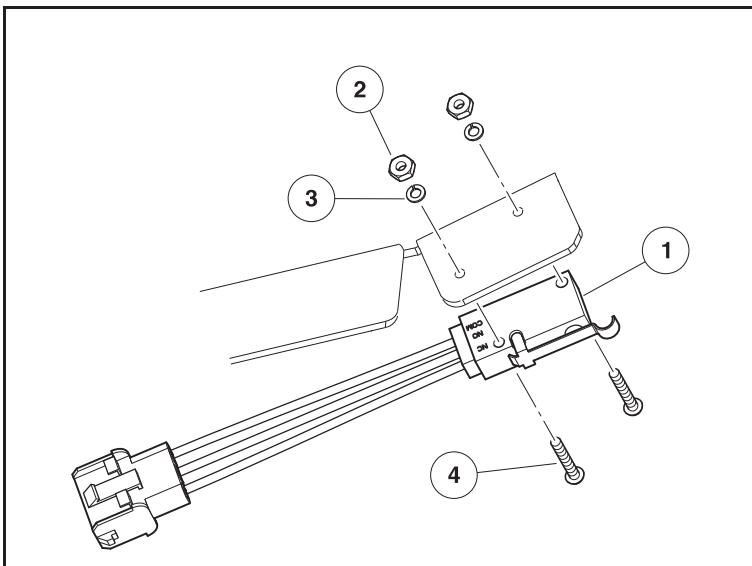
8. Connect the battery and spark plug wire.
9. Set the FNR to R. Make sure that the multi-purpose buzzer operates.

TRANSAXLE LIMIT SWITCH

See General Warnings on page 1-2.

TRANSAXLE LIMIT SWITCH REMOVAL

1. Disable the vehicle.
2. Disconnect the battery and spark plug wire.
3. Disconnect the 3-wire connector from the transaxle limit switch (1) (Figure 20-29).



000999-003

Figure 20-29 Transaxle Limit Switch

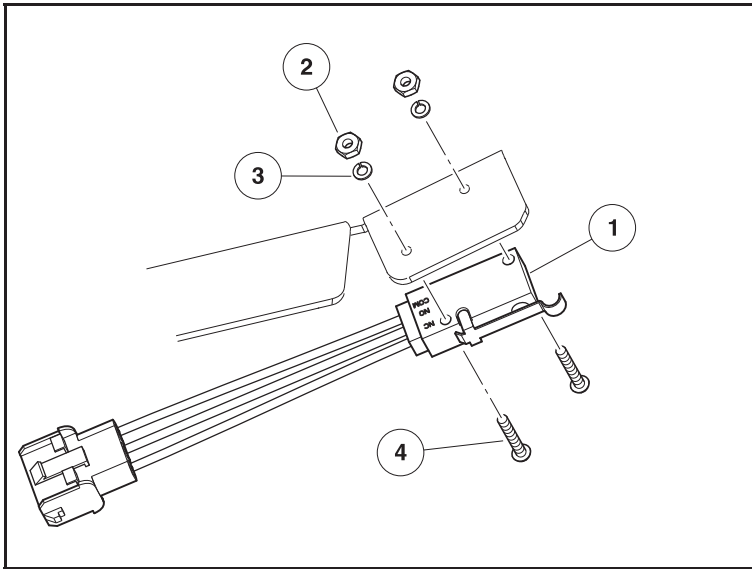
4. Remove the nuts (2), washers (3), and bolts (4).
5. Remove the transaxle limit switch.

TRANSAXLE LIMIT SWITCH INSTALLATION

⚠ CAUTION

- Do not overtighten the retaining nuts. If the nuts are overtightened, limit switches could be damaged.

1. Install the limit switch (1) with the bolts (4), washers (3), and nuts (2). Tighten the hardware to 5 in·lb (0.6 N·m) (Figure 20-30).

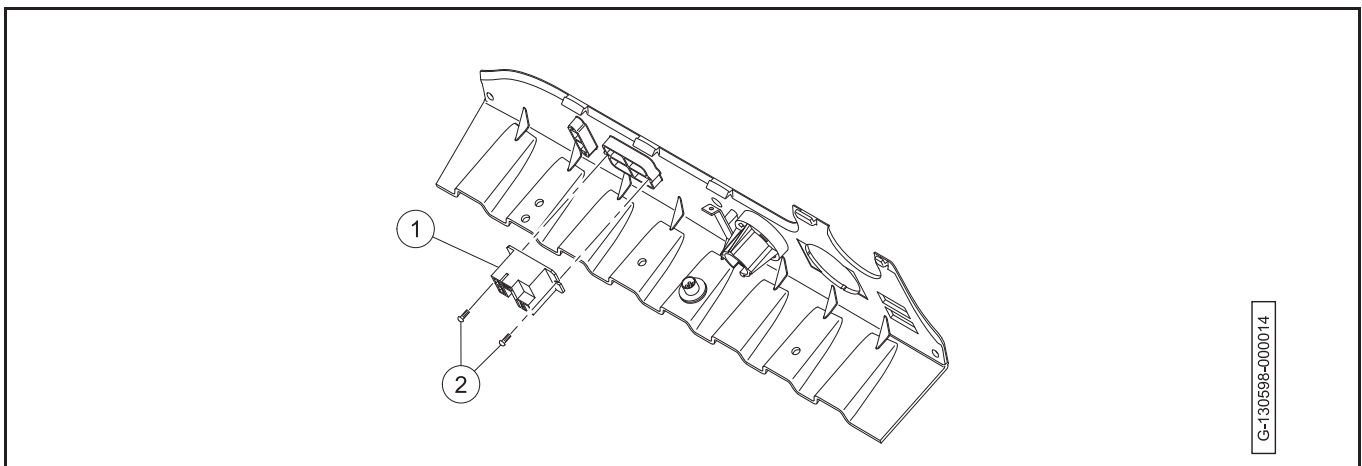


000999-003

Figure 20-30 Transaxle Limit Switch

2. Move the Forward/Neutral/Reverse control (FNR) to make sure that the switch actuates.
3. Connect the 3-wire connector to the transaxle limit switch lead.
4. Connect the battery and spark plug wire.
5. Test drive the vehicle in both forward and reverse for proper operation.

BRAKE LIGHT RELAY

**Figure 20-31 Brake Light Relay**

BRAKE LIGHT RELAY REMOVAL

1. Disconnect the battery and spark plug.
2. Remove the instrument panel.
3. Disconnect the wires from brake light relay (1) (**Figure 20-31, Page 20-28**).

4. Remove the screws (2).
5. Remove the brake light relay.

BRAKE LIGHT RELAY INSTALLATION

1. Install the brake light relay (1) on the instrument panel (Figure 20-31, Page 20-28).
2. Install the screws (2).
3. Connect the wires to the brake light relay terminals (Figure 20-32, Page 20-29).

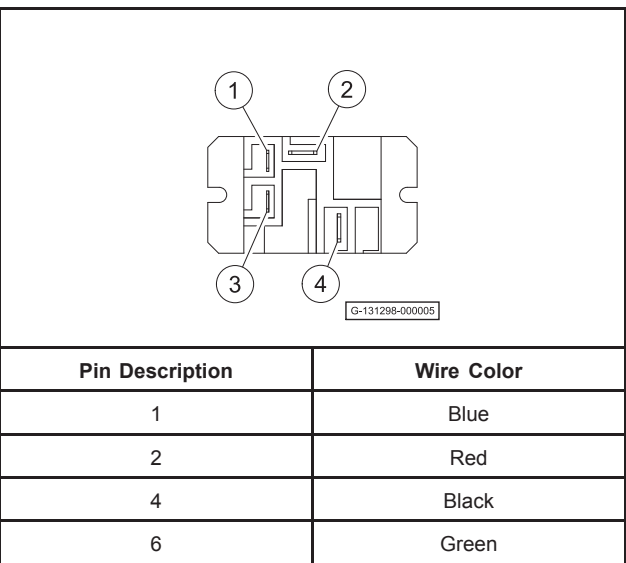


Figure 20-32 Brake Light Relay Terminals

4. Install the instrument panel.
5. Connect the battery and spark plug wire.

FUEL GAUGE/HOUR METER

GENERAL INFORMATION

With the key switch in the OFF position, the fuel gauge field is blank; however, the hour meter field is always ON. When the key switch is turned to ON, the fuel gauge field activates. The fuel gauge initially registers full before indicating the actual fuel level.

The hour meter displays the number of hours of use in increments of 0.1 (one tenth) hour, but does not record additional time unless the key switch is in the ON position and the engine is on. When recording, the hourglass icon on the left blinks.

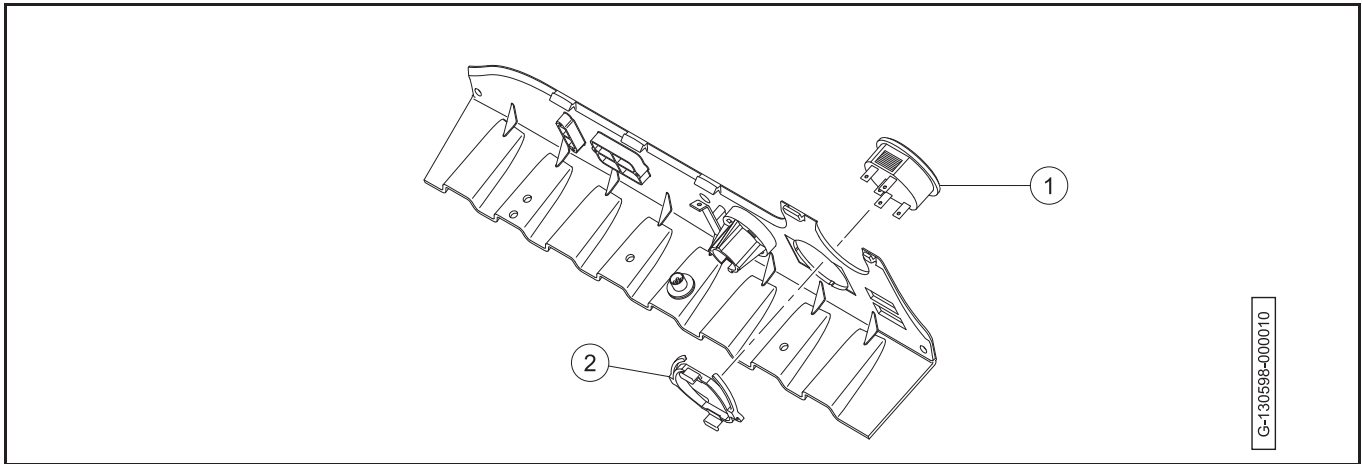


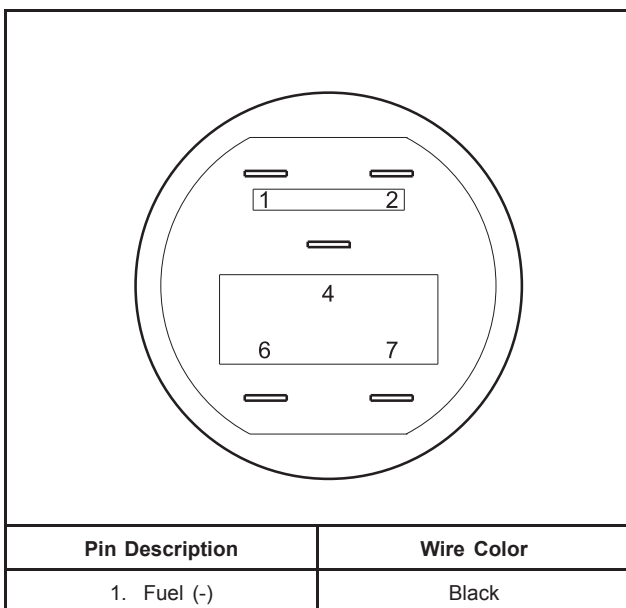
Figure 20-33 Fuel Gauge / Hour Meter

FUEL GAUGE/HOUR METER REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the wires from the fuel gauge/hour meter (1) (**Figure 20-33, Page 20-30**). Do not allow wires to touch.
4. Alternate pulling the lower and upper tabs away from the gauge housing (2) to remove clip.
5. Remove the fuel gauge/hour meter from the instrument panel.

FUEL GAUGE/HOUR METER INSTALLATION

1. Install the fuel gauge/hour meter (1) into the hole in the instrument panel until the flange seats against the instrument panel (**Figure 20-33, Page 20-30**).
2. Install the gauge housing (2).
3. Connect the wires to the fuel gauge/hour meter (**Figure 20-34, Page 20-30**).



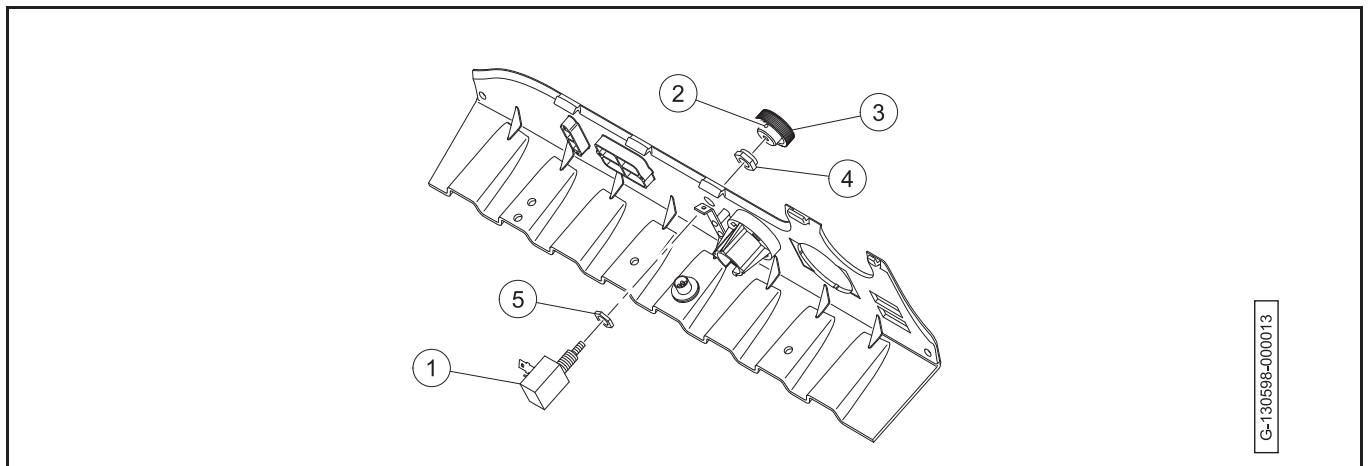
| | |
|---------------|-------------|
| 2. Fuel (+) | Blue |
| 4. Fuel Input | Orange |
| 6. Hour (-) | Black/White |
| 7. Hour Input | Red |

480

Figure 20-34 Fuel Gauge/Hour Meter

4. Install the instrument panel.
5. Connect the battery and spark plug wire.

HEADLIGHT SWITCH



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Figure 20-35 Headlight Switch

HEADLIGHT SWITCH REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the wires from the headlight switch (1) (**Figure 20-35, Page 20-31**).
4. Loosen the set screw (2).
5. Remove the threaded knob (3).
6. Remove the nut (4).
7. Remove the headlight switch and nut (5).

HEADLIGHT SWITCH INSTALLATION

1. Install the nut (5) onto the headlight switch (1) (**Figure 20-35, Page 20-31**).
2. Install the headlight switch into the instrument panel.
3. Install the nut (4). Tighten the nut to 2.2 lb·in (0.25 N·m).
4. Tighten the nut (5).
5. Install the threaded knob (3).
6. Tighten the set screw (2).

7. Connect the blue and yellow wires to the headlight switch terminals.
8. Install the instrument panel.
9. Connect the battery and spark plug wire.

KEY SWITCH

See General Warnings on page 1-2.

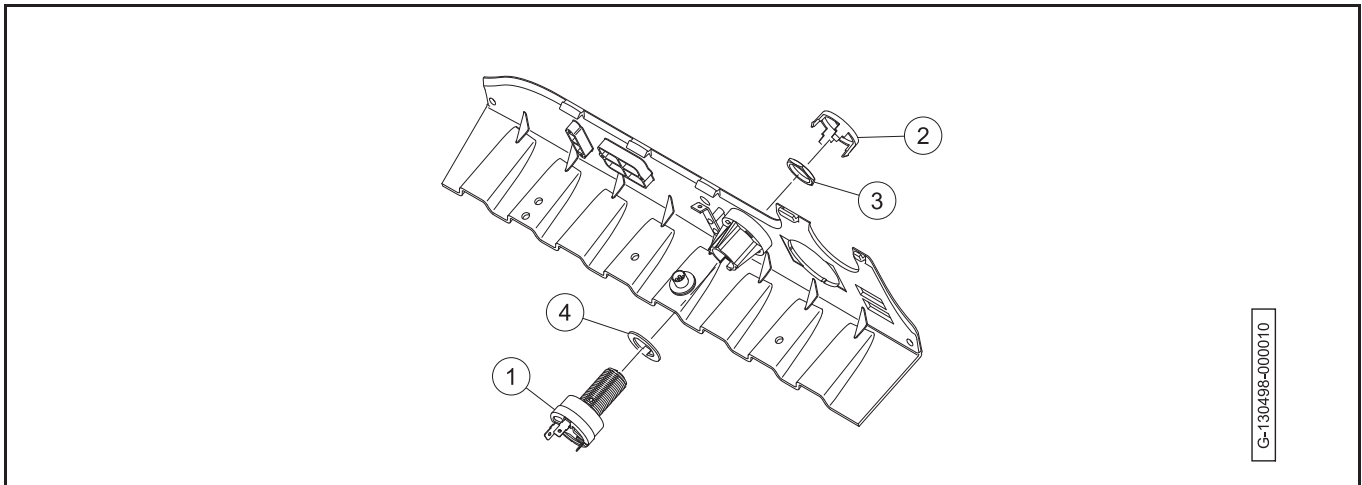


Figure 20-36 Key Switch

KEY SWITCH REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the wires from the key switch (1) (**Figure 20-36, Page 20-32**).
4. From the back of the instrument panel, push down on the retaining tabs and remove the key switch cap (2).
5. Hold the key switch and remove the switch retaining nut (3) from the outside of the instrument panel.
6. Remove the washer (4) and the key switch.

KEY SWITCH INSTALLATION

1. Install the key switch (1) and washer (4) into the instrument panel (**Figure 20-36, Page 20-32**).
2. Install the key switch nut (3). Tighten the nut to 35 to 45 lb·in (4 to 5 N·m).
3. Install the key switch cap (2).
4. Connect the wires to the key switch terminals. See the following table.

| Terminal | Wire Color |
|----------|------------|
| 1 | Blue |

TABLE CONTINUED ON NEXT PAGE

| | |
|----|---------------|
| 2 | Red |
| -M | Black |
| +M | White / Black |

5. Install the instrument panel.
6. Connect the battery and spark plug wire.

LOW OIL WARNING LIGHT

See General Warnings on page 1-2.

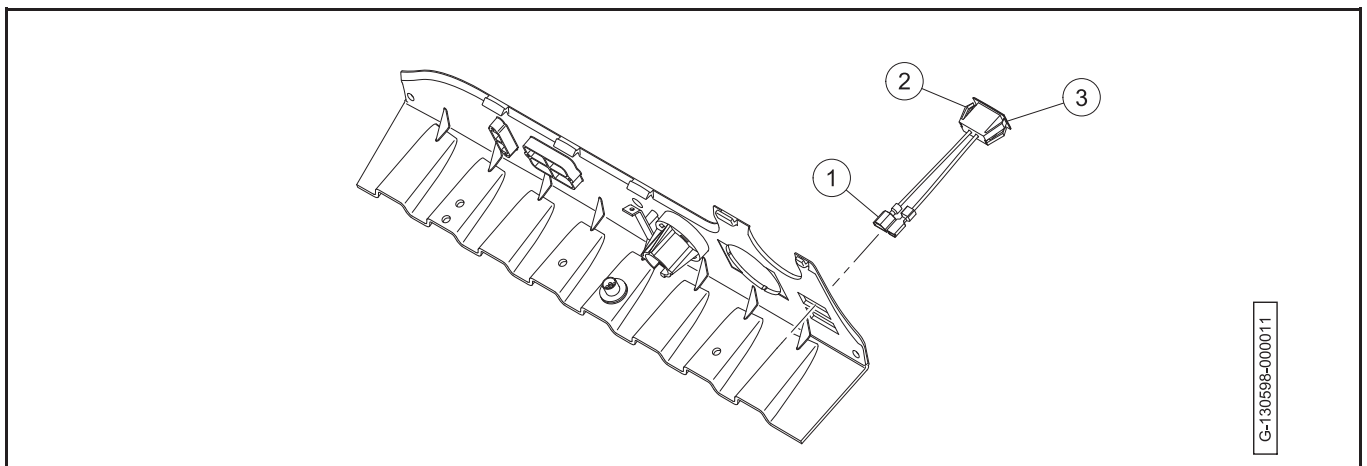


Figure 20-37 Low Oil Warning Light

LOW OIL WARNING LIGHT REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the wires (1) (**Figure 20-37, Page 20-33**).
4. Push the retaining tabs (2) and remove the low oil warning light (3).

LOW OIL WARNING LIGHT INSTALLATION

1. Push the low oil warning light (1) into the hole in instrument panel until retaining tabs engage (**Figure 20-37, Page 20-33**).
2. Connect the wires from the wire harness to the low oil warning light.
3. Install the instrument panel.
4. Connect the battery and spark plug wire.

MALFUNCTION INDICATOR LIGHT (MIL)

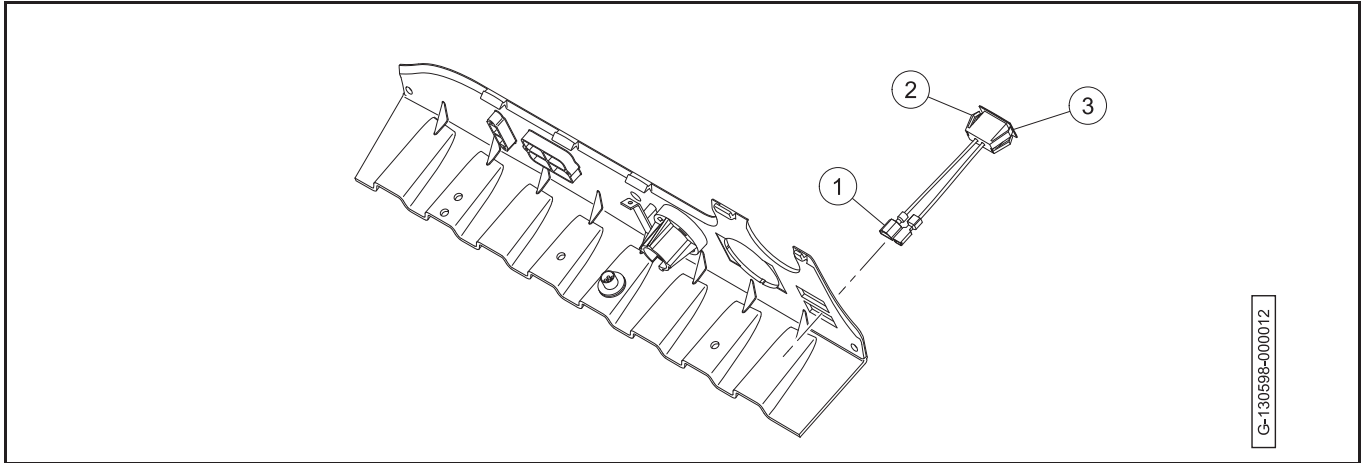


Figure 20-38 Malfunction Indicator Light (MIL)

MALFUNCTION INDICATOR LIGHT REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the wires (1) (**Figure 20-38, Page 20-34**). Do not allow wires to touch.
4. Push the retaining tabs (2) and remove the malfunction indicator light (3) from the instrument panel.

MALFUNCTION INDICATOR LIGHT INSTALLATION

1. Push the malfunction indicator light (MIL) (1) into the hole in instrument panel until retaining tabs engage (**Figure 20-38, Page 20-34**).
2. Connect the MIL wires.
3. Install the instrument panel.
4. Connect the battery and spark plug wire.

MULTI-PURPOSE BUZZER

See General Warnings on page 1-2.

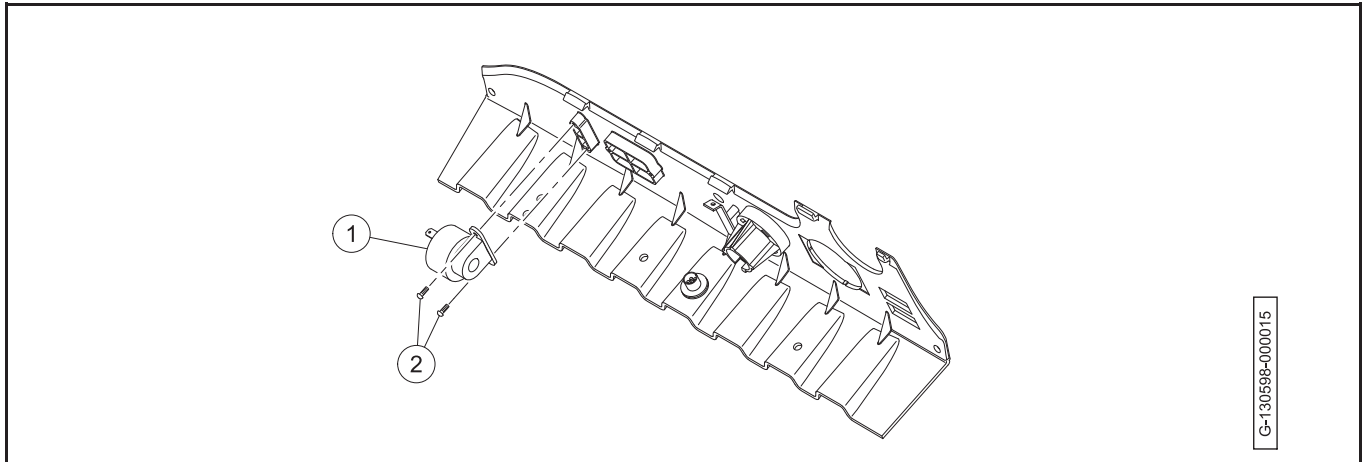


Figure 20-39 Multi-Purpose Buzzer

MULTI-PURPOSE BUZZER REMOVAL

1. Disconnect battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the wires from the multi-purpose buzzer (1) (**Figure 20-39, Page 20-35**).
4. Remove the two mounting screws (2).

MULTI-PURPOSE BUZZER INSTALLATION

1. Install the multi-purpose buzzer (1) onto the instrument panel (**Figure 20-39, Page 20-35**).
2. Install the screws (2). Tighten the screws to 3.5 lb·in (0.40 N·m).
3. Connect the black wire to the negative (–) terminal.
4. Connect the red/white wire to the positive (+) terminal.
5. Install the instrument panel.
6. Connect battery and spark plug wire.
7. Set the Forward/Neutral/Reverse control (FNR) to R. Make sure that the multi-purpose buzzer operates.

USB RECEPTACLE

The 5-volt, 2.1 amp USB receptacle supplies electricity to power and charge portable devices. The USB receptacle is not for movement of data.

The USB receptacle will only operate when a shielded USB cord is connected. When the USB receptacle is not in use, remove the shielded USB cord to prevent battery drain.

USB RECEPTACLE REMOVAL

1. Disconnect the battery and spark plug wire.
2. Remove the instrument panel.
3. Disconnect the USB receptacle wires (1 and 2) from the instrument panel wires (**Figure 20-40, Page 20-36**).

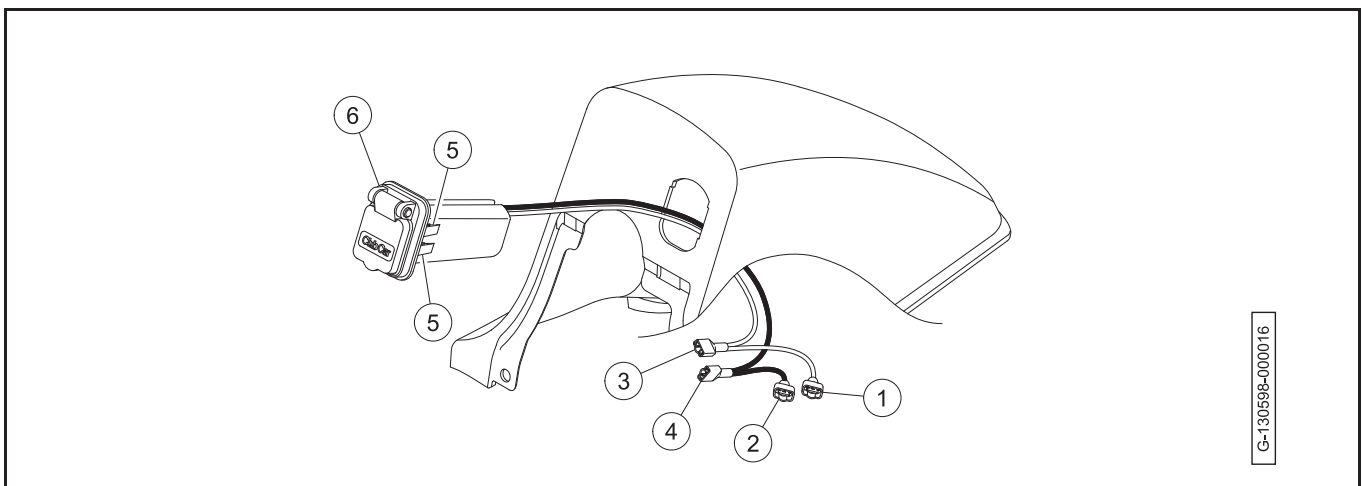


Figure 20-40 USB Receptacle

4. Disconnect the USB receptacle wires (3 and 4) from the key switch.
5. Push the lock tabs (5) on both sides and remove the USB receptacle (6).

USB RECEPTACLE INSTALLATION

1. Put the USB receptacle wires into the dash.
2. Push the USB receptacle (6) into the dash (**Figure 20-40, Page 20-36**).
3. Make sure that the locking tabs (5) engage.
4. Connect the red instrument panel wire to the red USB receptacle wire (1).
5. Connect the black instrument panel wire to the black USB receptacle wire (2).
6. Connect the red USB receptacle wire (3) to key switch 2 terminal.
7. Connect the black USB receptacle wire (4) to key switch M- terminal.
8. Install the instrument panel.
9. Connect the battery and spark plug wire.

OXYGEN SENSOR

OXYGEN SENSOR REMOVAL

1. Disconnect the battery.
2. Disconnect the oxygen sensor connector from the engine wire harness (1) (**Figure 20-41, Page 20-37**).

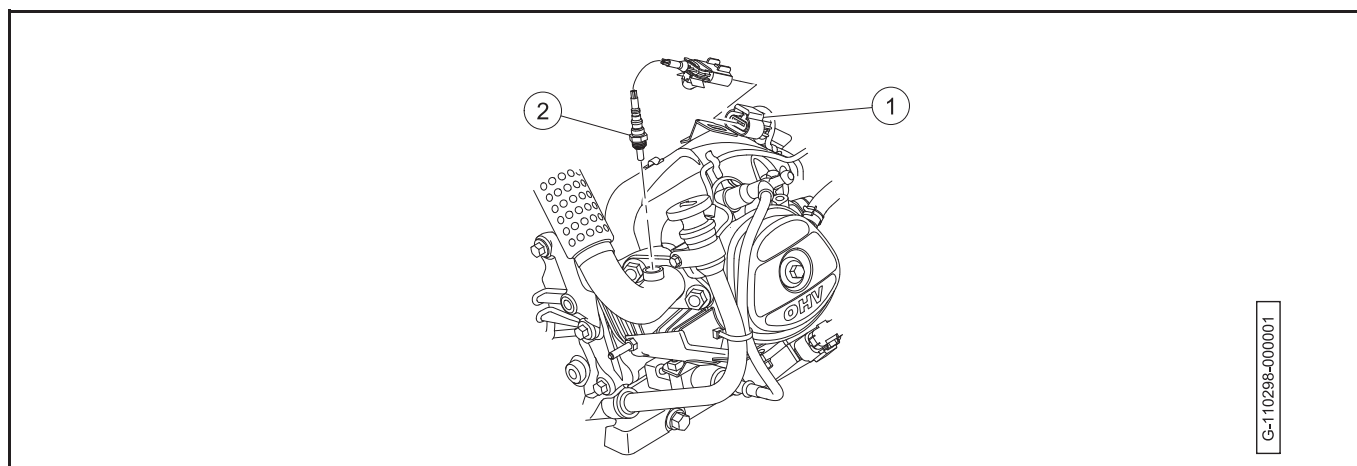


Figure 20-41 Oxygen Sensor

3. Remove the oxygen sensor (2).

OXYGEN SENSOR INSTALLATION

1. Install the oxygen sensor (2) into the muffler tube (**Figure 20-41, Page 20-37**). Tighten the oxygen sensor to 13.25 ft·lb (18 N·m).
2. Connect the oxygen sensor connector to the engine wire harness (1).
3. Connect the battery.

Pagination Page

DANGER

- See General Warnings on page 1-2.

WARNING

- See General Warnings on page 1-2.

GENERAL INFORMATION

This vehicle is powered by a Kohler, high-compression, chain driven, overhead valve engine (OHV). **See following NOTE.**

NOTE: *Engine rotation is counterclockwise as viewed from the clutch side of the engine.*

This section contains information for removing and replacing the engine and snubber.

For complete disassembly, rebuild, maintenance, and repair information,

BEFORE SERVICING

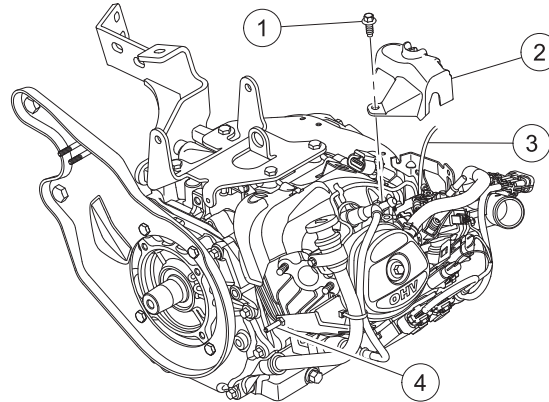
Carefully read the applicable information and instructions before beginning engine service. Diagrams, DANGER, WARNING, CAUTION and NOTE statements and detailed descriptions have been included wherever necessary. Anyone attempting engine service should have knowledge and experience in small engine service and repair.

ENGINE REMOVAL

⚠ CAUTION

- Before removal and disassembly, clean the engine.

1. Disconnect the battery.
2. Disconnect the spark plug wire.
3. For some vehicles, the engine can be removed by lifting it up and out of the chassis. For other vehicles, it is easier to remove the entire powertrain assembly first. If removing the powertrain, see Transaxle Removal.
4. Loosen the clamp and disconnect the air intake hose from the engine.
5. Disconnect the fuel line. See Fuel Line Removal.
6. Remove the screw (1) (Figure 21-1, Page 21-2)



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Figure 21-1 Governor Cover and Ground Cable Removal

7. Remove the governor cover (2).
8. Loosen the clamp and disconnect the vent line (3).
9. Disconnect the engine wire harness from the main harness.
10. Remove the governor cable. See Governor Cable Removal.
11. Remove the accelerator cable. See Accelerator Cable Removal.
12. Disconnect the ground cable from the engine (4).
13. Remove the starter/generator and belt. See Starter/Generator Removal.
14. Remove the drive clutch. See Drive Clutch Removal.
15. Remove the muffler. See Muffler Removal.

16. Remove the bolts (5 and 6) (Figure 21-2, Page 21-3).

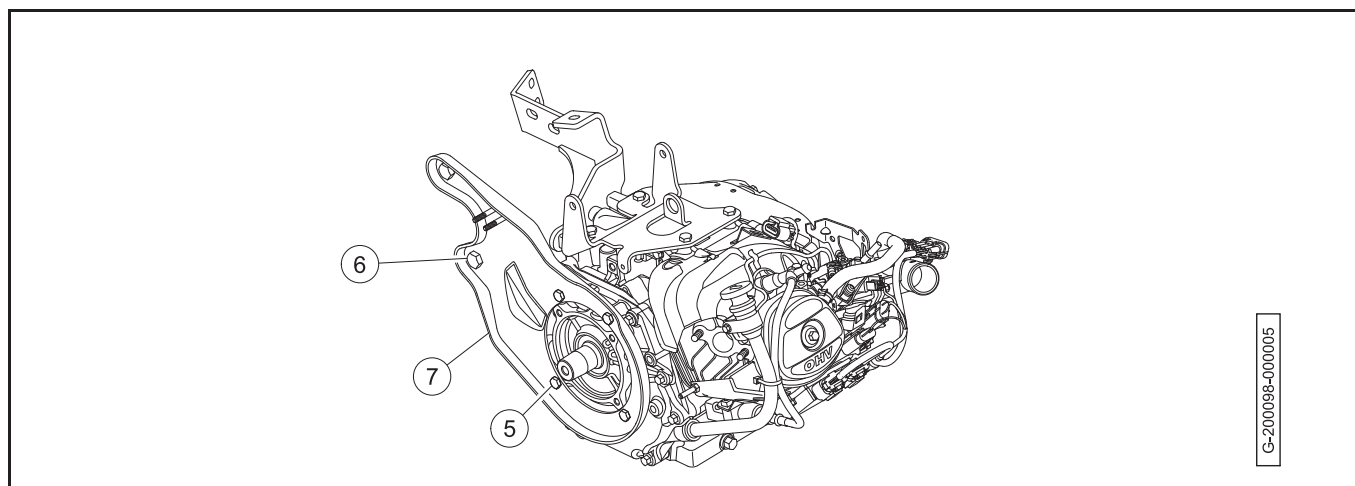


Figure 21-2 Clutch Plate Removal

17. Remove the clutch plate (7).
18. Remove the bolts (8) (Figure 21-3, Page 21-3).

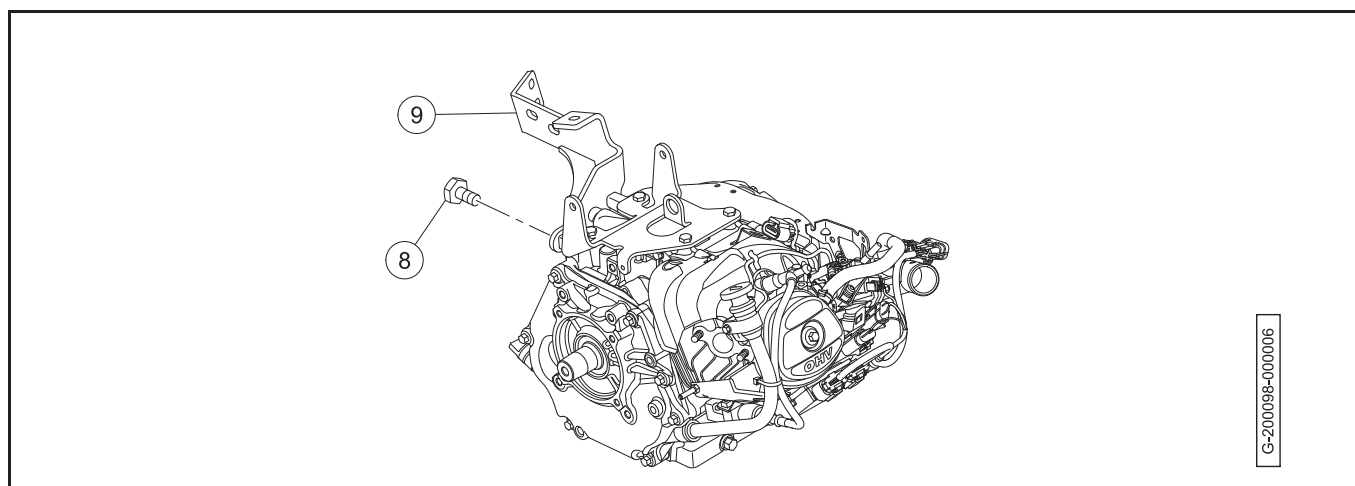


Figure 21-3 Exhaust Weldment Removal

19. Remove the exhaust weldment (9).

20. Remove the bolts (10), washers (11), and nuts (12) (Figure 21-4, Page 21-4).

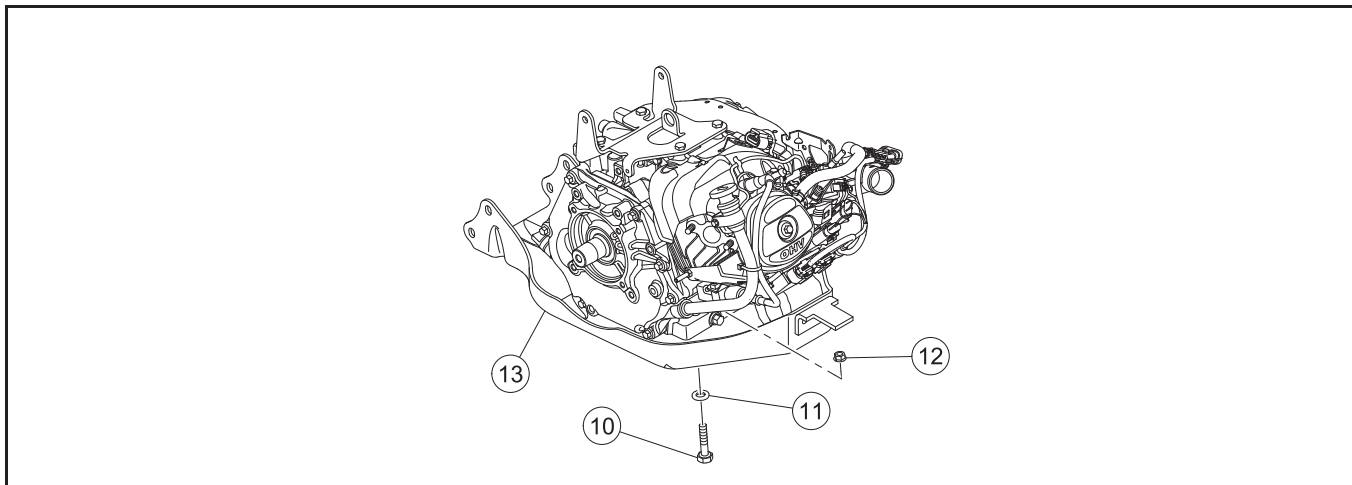


Figure 21-4 Engine Pan Removal

21. Lift the engine from engine pan (13). **See following NOTE.**

NOTE: The engine weighs approximately 54 lb (24.5 kg).

22. Remove the oil drain plug and drain all oil from crankcase. Dispose of engine oil properly.
23. If replacing the engine, remove the starter/generator mounting weldment and retain for installation on new engine. **See following NOTE.**

ENGINE INSTALLATION

1. If replacing engine, install starter/generator mounting weldment on engine with the screws. Tighten the screws to 17 ft·lb (23 N·m).
2. Install oil drain plug and tighten to 13 ft·lb (18 N·m).
3. Place the engine onto the engine pan (13) and secure with mounting hardware (10, 11, and 12) (**Figure 21-5, Page 21-5**). Tighten the nuts to 33 ft·lb (40.6 N·m).

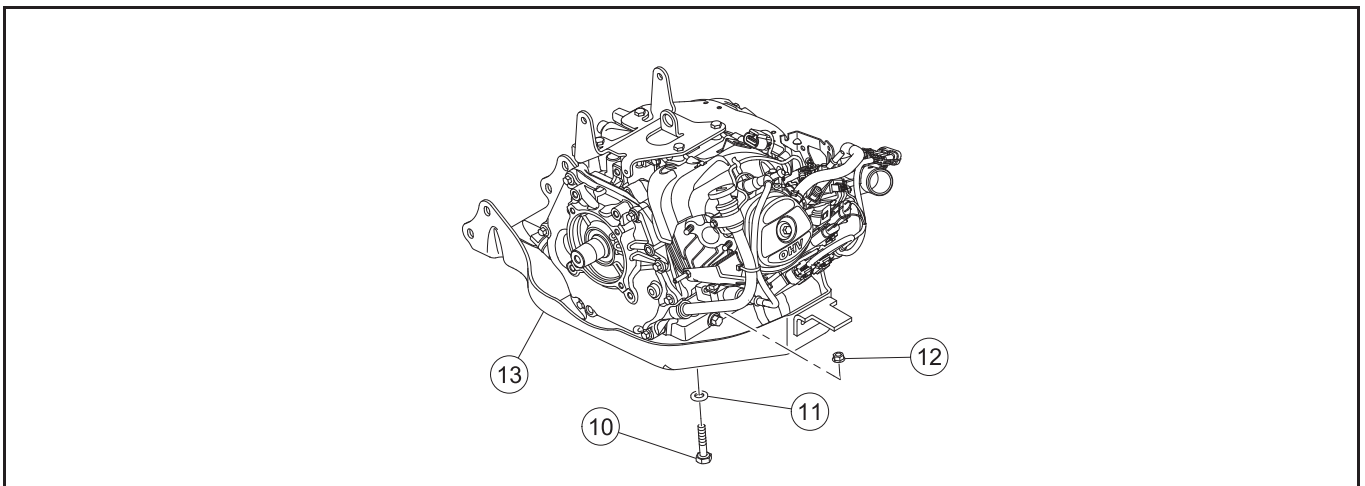


Figure 21-5 Engine Pan Installation

4. Install the muffler weldment (9) with the bolts (8) (**Figure 21-6, Page 21-5**). Tighten the bolts to 18 ft·lb (24 N·m).

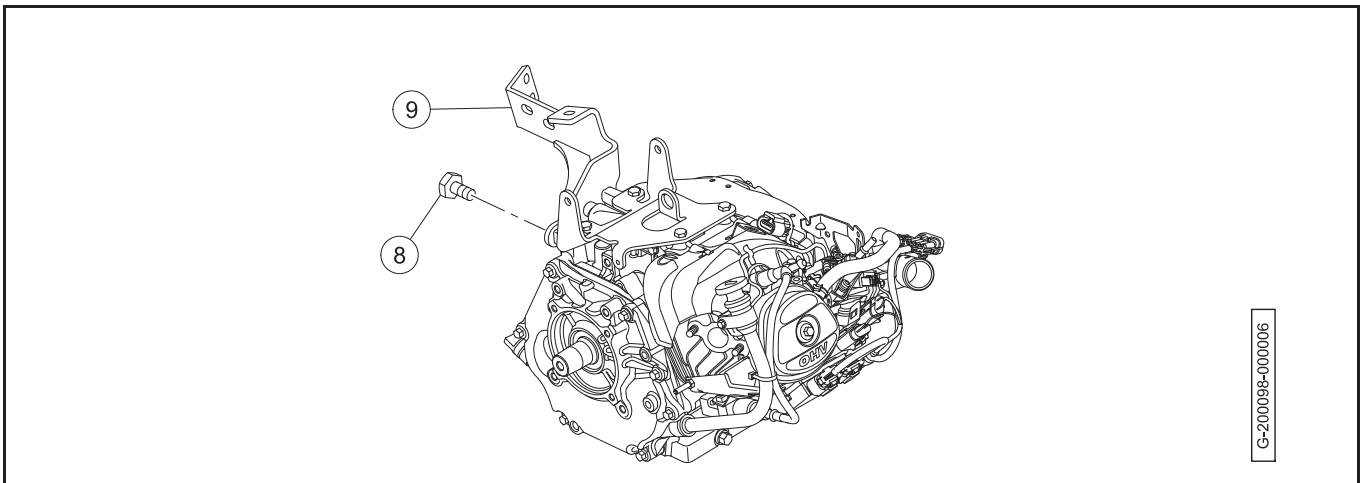


Figure 21-6 Exhaust Weldment Installation

5. Install the clutch plate (7) with bolts (5 and 6) (**Figure 21-7, Page 21-6**). Tighten the bolts (5) to 27 ft·lb (36 N·m). Tighten the bolts (6) to 50 ft·lb (68 N·m).

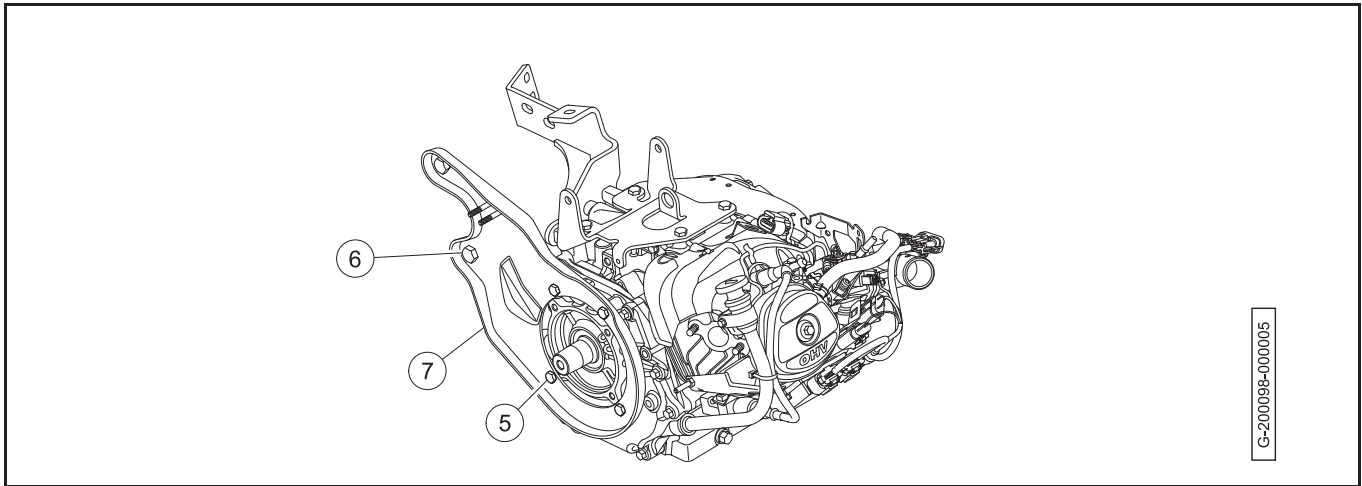


Figure 21-7 Clutch Plate Installation

6. Install the drive clutch. See Drive Clutch Installation.
7. Install the muffler. See Muffler Installation.
8. Install the starter/generator and belt. See Starter/Generator Installation.
9. If necessary, install the powertrain. See Transaxle Installation.
10. Install the governor cable. See Governor Cable Installation and Adjustment.
11. Install the accelerator cable. See Accelerator Cable Installation and Adjustment.
12. Secure the accelerator cable and governor cable P-clamps to engine. Tighten the P-clamp bolts to 36 in·lb (4.0 N·m).
13. Connect the air intake hose. See Air Cleaner Installation.
14. Install the fuel line. See Fuel Line Installation.
15. Connect the engine wire harness to the main wire harness.

16. Connect the ground cable to the engine (4) (Figure 21-8, Page 21-7).

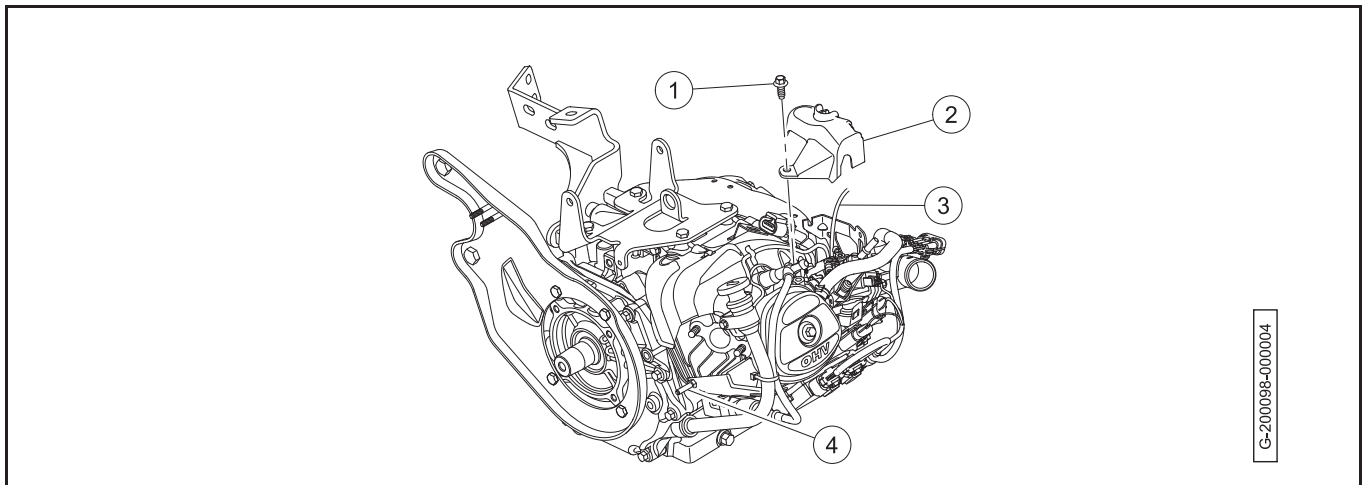


Figure 21-8 Governor Cover and Ground Cable Installation

17. Route the vent line (3) through the governor cover (2).
18. Connect the vent line.
19. Install the governor cover with the screw (1). **Torx Head:** Tighten the screw to 36 in·lb (4.0 N·m). **Hex Head:** Tighten the screw between 75 to 85 in·lb (8.48 to 9.6 N·m).
20. Check all hardware for proper torque/tightness.
21. Fill engine to proper level with correct type of oil. See Vehicle Specifications.

⚠ CAUTION

- Do not overfill with oil.

22. Connect the battery and spark plug wire.
23. Adjust the idle. See **ECU Reset Procedure** and **TPS Learn Procedure for Pedal Start Applications** in the Kohler Service Manual.
24. Adjust the engine RPM setting. See Engine RPM Adjustment.
25. Test-drive vehicle to ensure all systems are functional and correctly adjusted.

SNUBBER

NOTE: The snubber is installed on the gasoline vehicle only.

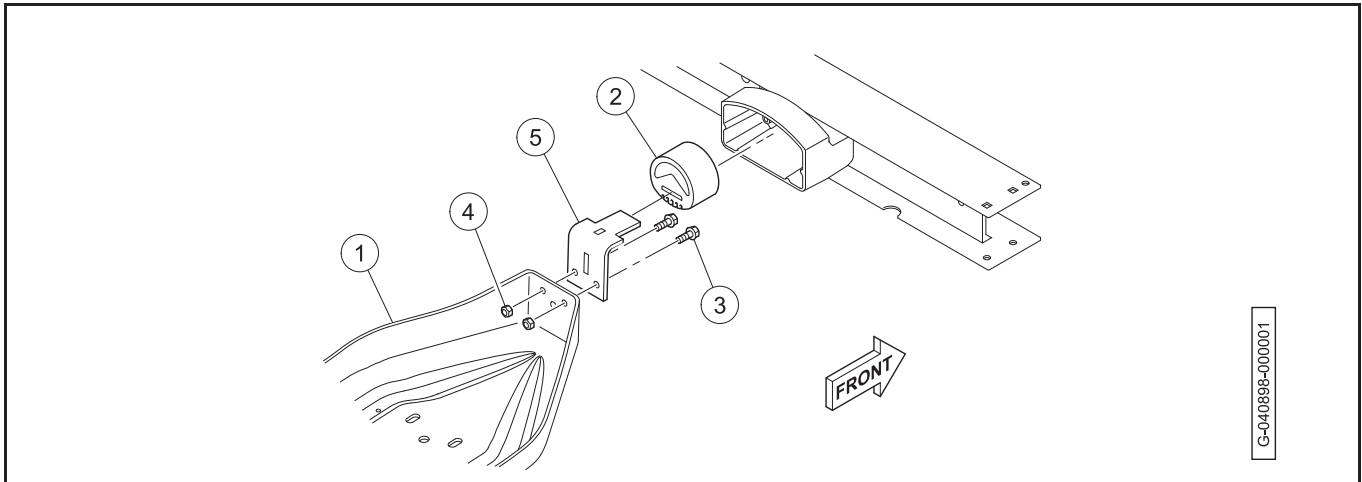


Figure 21-9 Snubber

SNUBBER REMOVAL

1. Support the powertrain with a floor jack under the engine pan (1) so that the snubber (2) is raised slightly and does not rest on the vehicle frame (**Figure 21-9, Page 21-8**).
2. Remove the two bolts (3) and two lock nuts (4) securing the snubber bracket (5) to the engine pan.
3. Slide the snubber and snubber bracket assembly toward the battery to remove it from vehicle.
4. Slide the snubber off the snubber bracket.

SNUBBER HOUSING AND SPACER REMOVAL

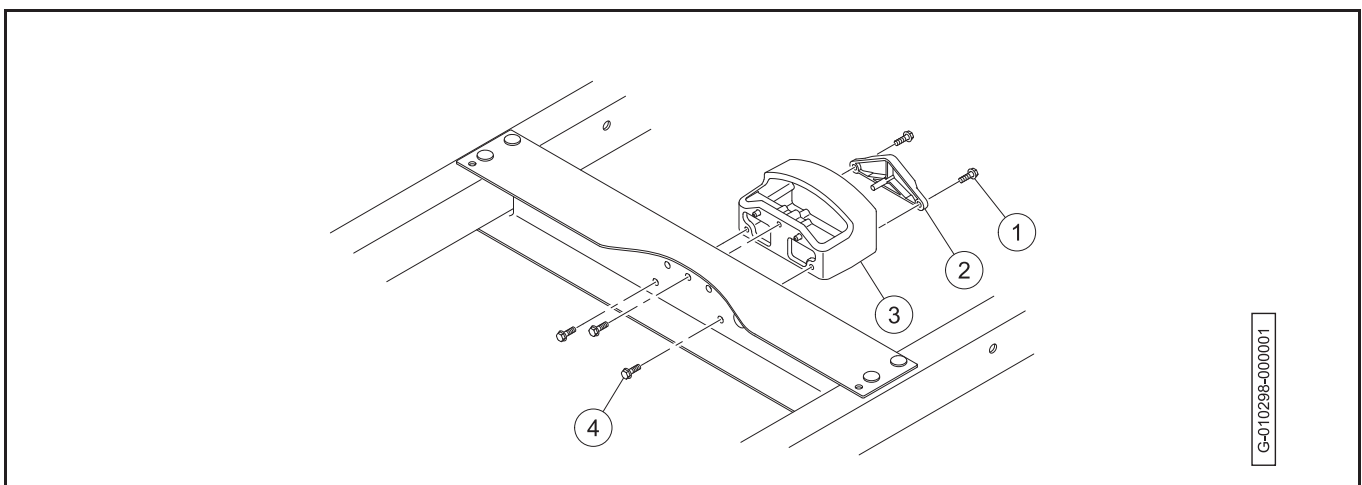


Figure 21-10 Snubber Housing and Spacer

1. Remove the two bolts (1) securing the snubber spacer (2) to the snubber housing (3) **(Figure 21-10, Page 21-8)**.
2. Remove the three bolts (4) securing the snubber housing to the vehicle frame.
3. Remove the snubber housing from the vehicle frame.

SNUBBER HOUSING AND SPACER INSTALLATION

1. Install the snubber housing (3) onto the vehicle frame **(Figure 21-10, Page 21-8)**.
2. Align the holes in the snubber housing with the holes in the vehicle frame.
3. Attach the snubber housing to the vehicle frame with the three bolts (4). Tighten the bolts from 6.6 to 8.1 ft·lb (9 to 11 N·m).
4. Slide the snubber spacer (2) into the snubber housing.
5. Attach the snubber spacer to the snubber housing with the two bolts (1). Tighten the bolts from 3.7 to 5.1 ft·lb (5 to 7 N·m).

SNUBBER INSTALLATION

1. Slide the snubber (2) onto the snubber bracket (5) **(Figure 21-9, Page 21-8)**.
2. Install the snubber bracket and snubber assembly onto engine pan (1).
3. Install the bolts (3) and lock nuts (4). Tighten the lock nuts (4) from 20 to 25 ft·lb (27.1 to 33.9 N·m).

Pagination Page

⚠ DANGER

- See General Warnings on page 1-2.

⚠ WARNING

- See General Warnings on page 1-2.

⚠ WARNING

- Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine.

GENERAL INFORMATION

The engine is equipped with a throttle body/fuel injector assembly that is controlled by an ECU and requires no adjustment. The ECU monitors engine conditions through inputs from a Manifold Absolute Pressure (MAP) sensor, engine block temperature sensor and ignition timing.

EFI SYSTEM FEATURES/SPECIFICATIONS

- The fuel pump operating pressure is 50 psi +/- 3. The Kohler fuel pressure gauge has a psi variance of +/- 3.
- Fuel pump operates for a few seconds when key switch is turned to the ON position; it stops if no engine RPM is detected by the ECU
- The ECU indicates a fault code through the malfunction indicator light (MIL)
- In-tank fuel pump
- Return-less system
- High fuel pressure system
- Controls fuel pump, fuel injector, and oil lamp
- Automatic altitude compensation
- Closed-loop system (includes oxygen sensor)
- Separate EFI wire harness
- Fail-safe function

ENGINE CONTROL LINKAGES

⚠ DANGER

- To ensure the vehicle does not run over you while you disconnect or adjust the accelerator push cable, do the following:
 - Turn key switch OFF and remove key, place Forward/Neutral/Reverse handle in the NEUTRAL position, and chock the wheels prior to servicing the vehicle.
 - Disconnect battery cables, negative (–) cable first.
 - Disconnect the spark plug wire from the spark plug.
 - See Disconnect the Battery - Gasoline Vehicles on page 1-3.

GENERAL INFORMATION

For proper vehicle operation, it is important the accelerator pedal, governor linkage, and throttle adjustments are done correctly and in the proper sequence. **See following CAUTION.**

⚠ CAUTION

- Improper adjustment can result in poor vehicle performance and/or damage to the engine components.

GROUND SPEED

NOTE: If possible, the manufacturer recommends measuring ground speed when setting engine RPM.

This vehicle should reach the forward ground speed specified in the Vehicle Specifications Section.

GOVERNOR CABLE

Governor Cable Removal

1. Turn the key switch to the OFF position and remove the key, place the Forward/Neutral/Reverse control (FNR) in the NEUTRAL position, and chock the wheels.
2. Disconnect battery and spark plug wire.
3. At engine:
 - 3.1. If equipped, remove air deflector from top of engine.

- 3.2. Remove the governor cable fitting (1) from the linkage retainer (2) (**Figure 22-1, Page 22-3**).

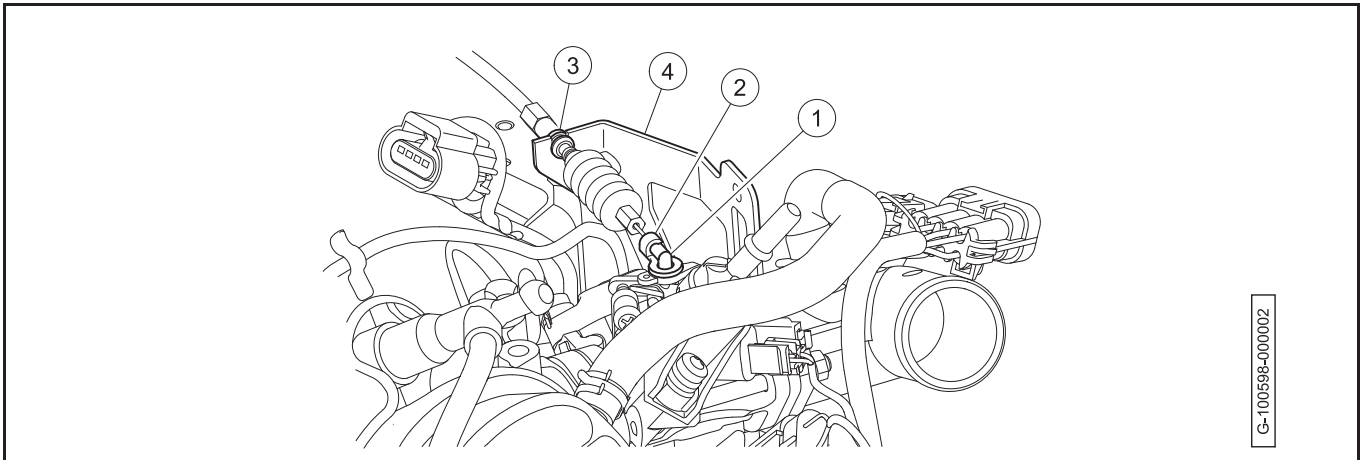


Figure 22-1 Governor Cable Removal - Throttle Body

- 3.3. Disconnect the governor cable fitting from throttle lever (3).
 3.4. Unsnap governor cable from throttle body bracket (4).
 4. At transaxle:
 4.1. Disconnect "Z" fitting of governor cable (1) from governor arm (2) (**Figure 22-2, Page 22-3**).

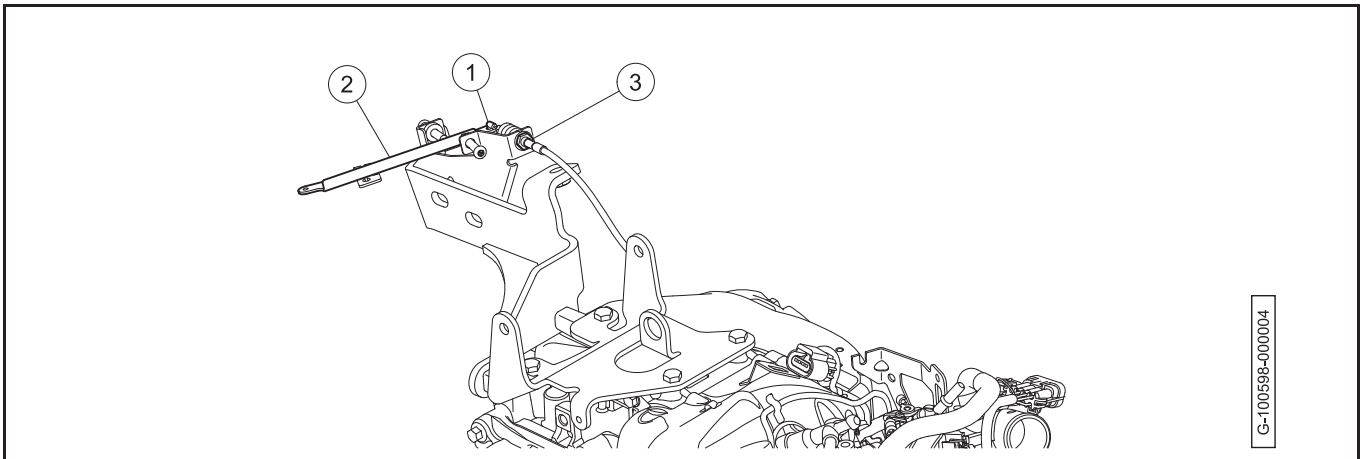


Figure 22-2 Governor Cable Removal - Governor Arm

- 4.2. Loosen jam nuts at governor bracket (3) and remove the governor cable from vehicle.

Governor Cable Installation and Adjustment

1. At engine:
 1.1. Snap governor cable into throttle body bracket (4) (**Figure 22-3, Page 22-4**).

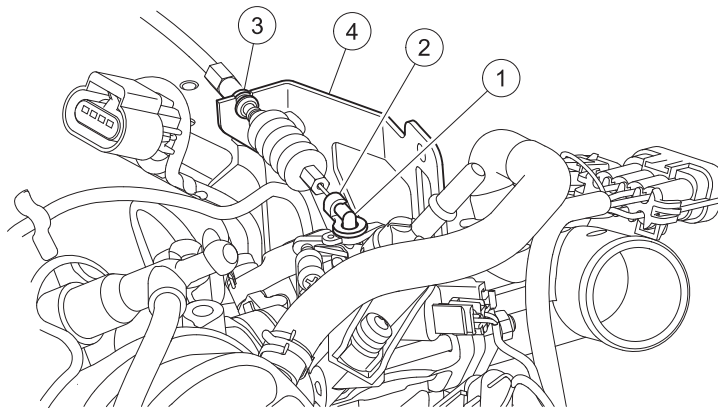


Figure 22-3 Governor Cable Installation - Throttle Body

- 1.2. Connect the governor cable fitting (1) to throttle lever (2).
- 1.3. Install the governor cable fitting into the linkage retainer (3).
2. At transaxle:
 - 2.1. Slide bellows off threaded end of cable housing, separate jam nuts and place threaded end into governor bracket (4) (**Figure 22-4, Page 22-4**).

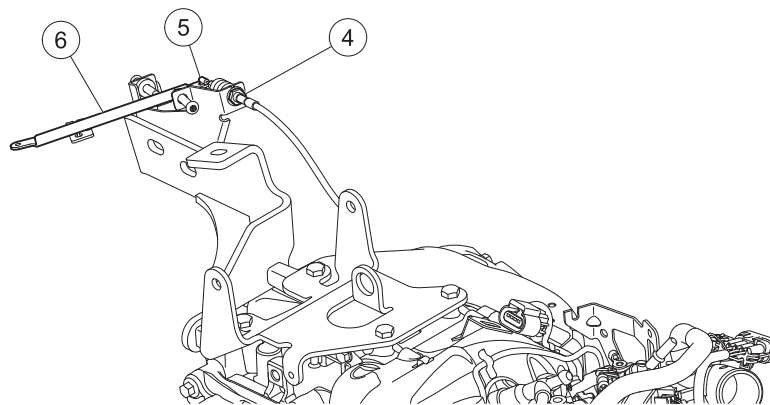


Figure 22-4 Governor Cable Installation - Governor Arm

- 2.2. Finger-tighten the jam nuts.
- 2.3. Push bellows back onto threaded end of cable housing.
- 2.4. Connect "Z" fitting of governor cable (5) to governor arm (6).

3. Adjustment:

- 3.1. Connect the diagnostic tool.
- 3.2. Loosen the jam nuts (7 and 11) and back off the throttle stop screws (8 and 12) several turns (**Figure 22-5, Page 22-5**).

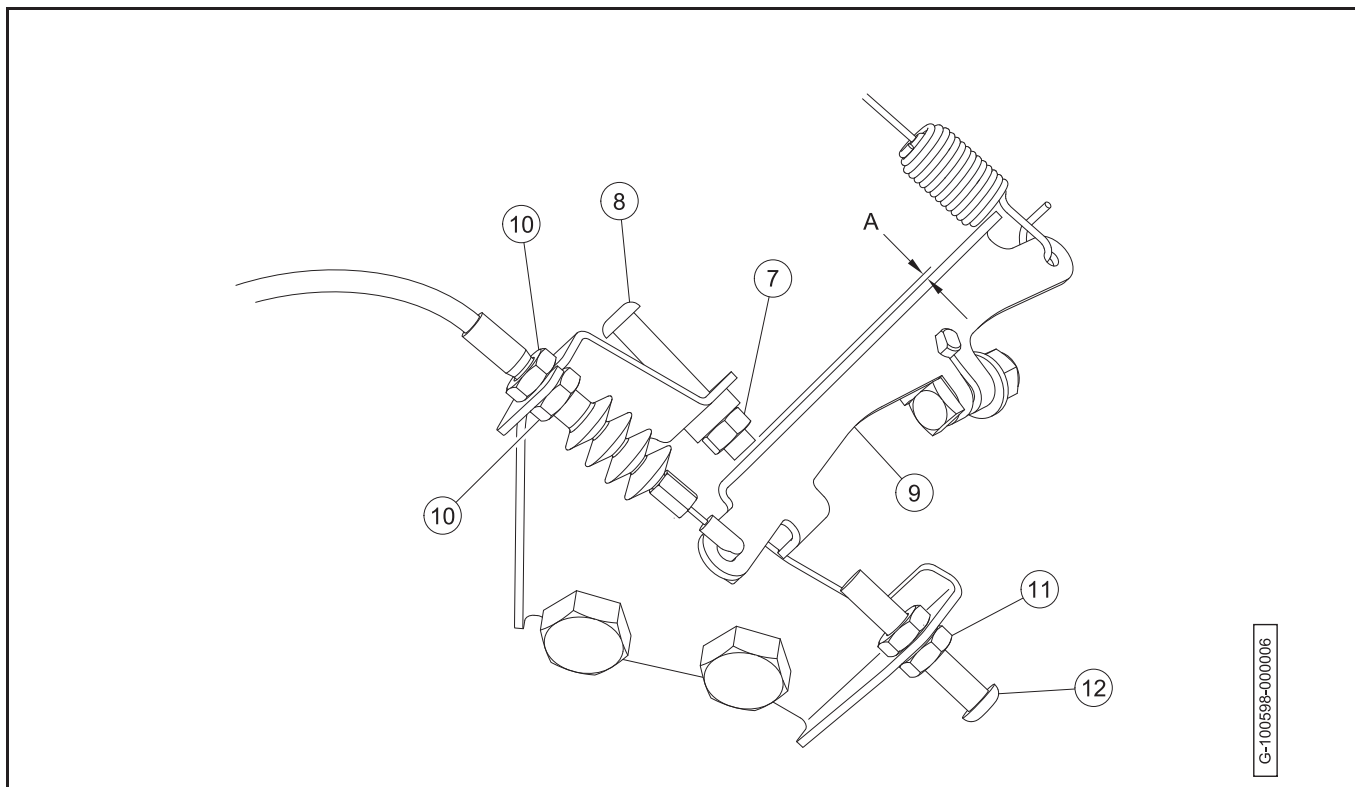


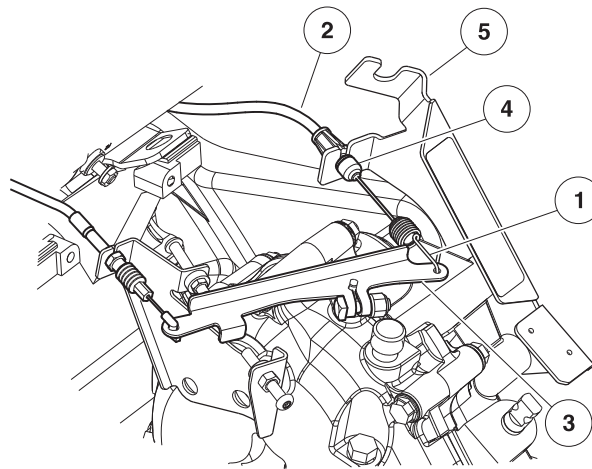
Figure 22-5 Governor Cable Adjustment

- 3.3. Rotate the governor arm (9) counterclockwise until it stops and hold in this position.
- 3.4. Adjust the governor cable jam nuts (10) until throttle position sensor is at 100% on the diagnostic tool. Tighten the governor cable jam nuts to 36 in·lb (4.0 N·m).
- 3.5. Release the governor arm to return to "idle" position.
- 3.6. Adjust the gap (A) between governor arm and stop screw (8) to 0.055 in. (± 0.039) (1.4 mm (± 1)). Tighten the jam nut (7) to 36 in·lb (4.0 N·m).
- 3.7. Rotate the governor arm counterclockwise.
- 3.8. Adjust the stop screw (12) until the throttle position sensor is between 75 - 80%. Tighten the jam nut (11) to 36 in·lb (4.0 N·m).
- 3.9. Check engine RPM adjustment. See Engine RPM Adjustment.

ACCELERATOR CABLE

Accelerator Cable Removal

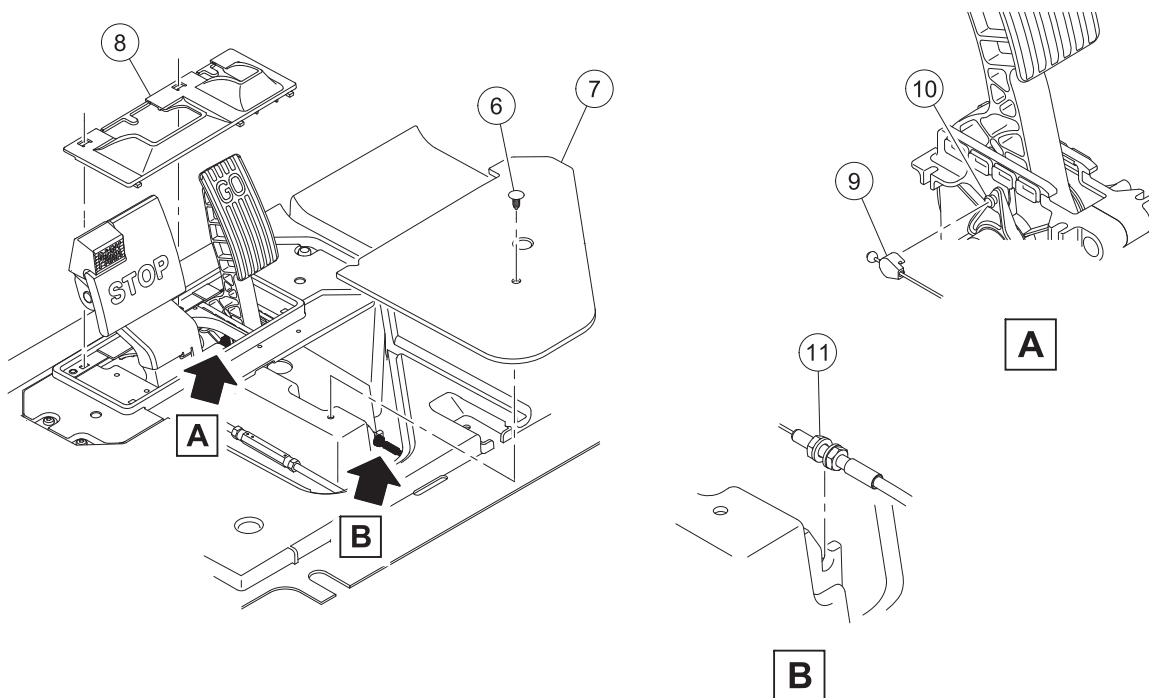
1. Disable the vehicle.
2. Disconnect the battery and spark plug wire.
3. Remove the P-clamps that secure the accelerator cable to the engine assembly.
4. At transaxle:
 - 4.1. Unhook the spring fitting (1) of accelerator cable (2) from governor arm (3) (**Figure 22-6, Page 22-6**).



3130B

Figure 22-6 Accelerator Cable At Transaxle

- 4.2. Remove the dust shield (4) from the end of the cable housing.
- 4.3. Unsnap the accelerator cable from FNR/accelerator cable bracket (5).
5. At pedal group:
 - 5.1. Remove the floor mat.
 - 5.2. Remove the push rivet (6) (Figure 22-7, Page 22-6).

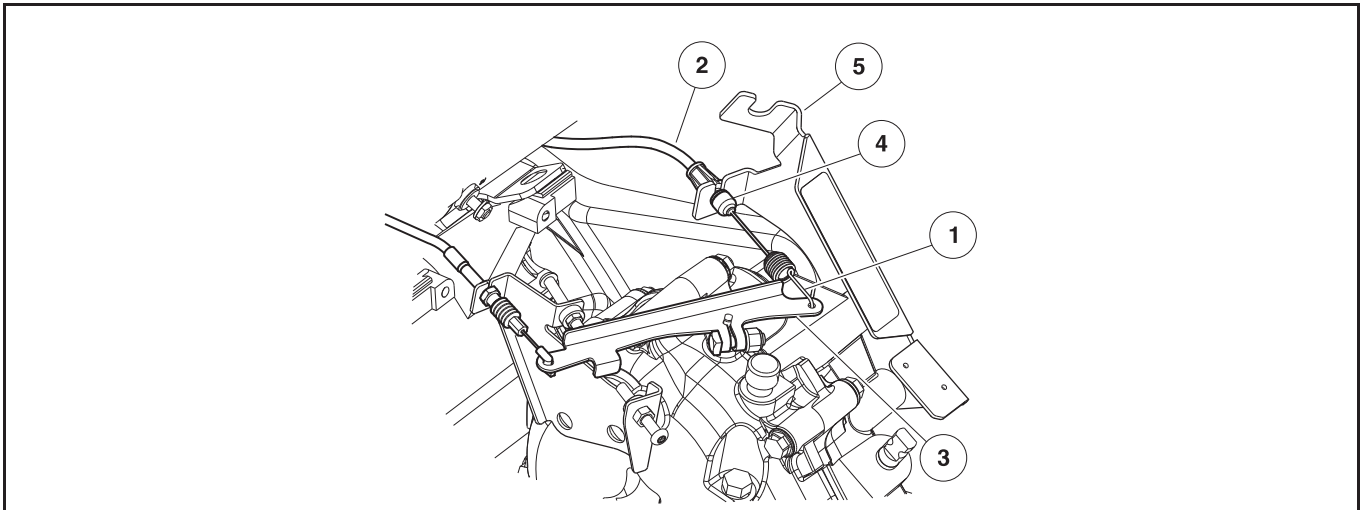
**Figure 22-7 Accelerator Cable At Pedal Group**

- 5.3. Remove the floor cover plate (7).

- 5.4. Remove the debris shield (8).
- 5.5. Disconnect the accelerator cable clip (9) from the accelerator pedal (10).
- 5.6. Loosen the jam nuts (11) and remove accelerator cable from vehicle.

Accelerator Cable Installation

1. At transaxle:
 - 1.1. Hook the spring fitting (1) of accelerator cable (2) to governor arm (3) (**Figure 22-8, Page 22-7**).



3130B

Figure 22-8 Accelerator Cable At Transaxle

- 1.2. Snap the accelerator cable into FNR/accelerator cable bracket (5).
- 1.3. Push the dust shield (4) onto end of cable housing.
2. At pedal group:
 - 2.1. Insert the accelerator cable through the hole in the frame and feed it towards the pedal group.
 - 2.2. Connect the accelerator cable clip (9) to the accelerator pedal (10) (**Figure 22-9, Page 22-8**).

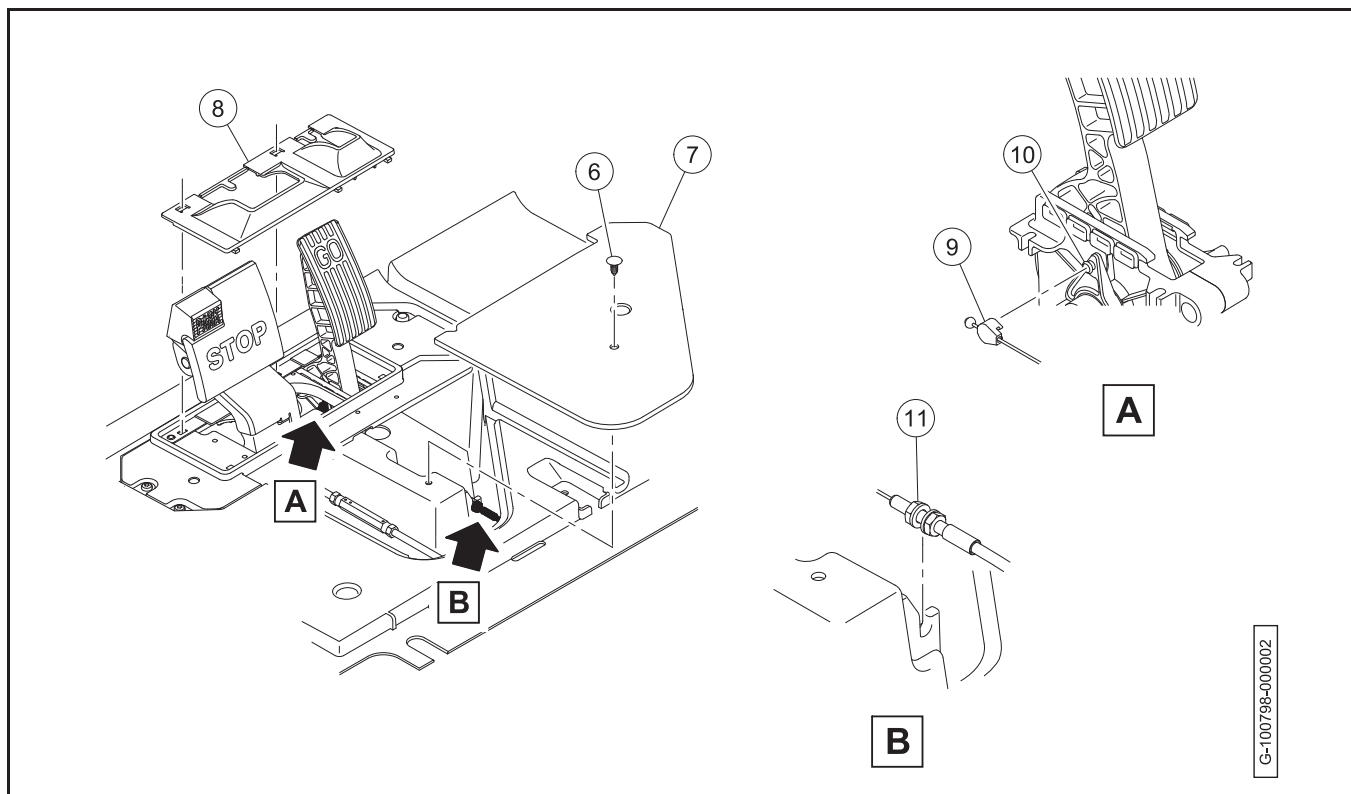


Figure 22-9 Accelerator Cable At Pedal Group

- 2.3. Install the debris shield (8).
- 2.4. Separate the jam nuts (11) on cable and put the threaded end into slot in underbody. Tighten the jam nuts finger-tight.
- 2.5. Before tightening the accelerator cable jam nuts, adjust the engine RPM. See Engine RPM Adjustment.
- 2.6. Install the floor cover plate (7).
- 2.7. Install the push rivet (6).
- 2.8. Install the floor mat.
3. Connect the battery and spark plug wire(s).

IDLE ADJUSTMENT

To adjust the idle, see **ECU Reset Procedure** and **TPS Learn Procedure for Pedal Start Applications** in the Kohler Service Manual.

HOW TO MEASURE GROUND SPEED

Best Method

An easy way to check ground speed is by using a GPS device or smartphone application (app). If these are not available, use the alternate method below.

Alternate Method (Calculated)

Ground speed is easily determined by a known distance travelled, divided by the amount of time it took to travel that known distance ($Rate = Distance/Time$).

1. Establish a known distance to travel (example: 100 ft. (30.5 m) in a safe location using cones or other type of marker.

2. Drive vehicle and bring to maximum speed before reaching the first cone.
3. Using a stopwatch, record the amount of time it takes to travel from the first cone to the second cone at maximum speed.
4. With distance and time determined, calculate ground speed:
 - 4.1. **Rate in seconds:** Divide distance (100 ft (30.5 m)) by time (5 seconds) = 20 ft/sec (6.1 m/sec).
 - 4.2. **Convert seconds to hour:** Multiply 20 ft/sec (6.1 m/sec) by 3600 (the number of seconds in an hour) = 72000 ft/hour (21960 m/hour)
 - 4.3. **Convert to MPH:** Divide 72000 ft/hour by 5280 (number of ft in 1 mile) = 13.64 miles/hour
Convert to KPH: Move the decimal point over three places; 21960 m/hour = 21.96 km/hour

ENGINE RPM ADJUSTMENT

DANGER

- Do not operate gasoline vehicle in an enclosed area without proper ventilation. The engine produces carbon monoxide, which is an odorless, deadly poison.

1. If governor is adjusted, proceed to step 2; otherwise, adjust governor. **See Governor Cable Installation and Adjustment on page 22-3.**
2. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.
3. Measure vehicle ground speed. **See How to Measure Ground Speed on page 22-8.**
4. Compare measured ground speed with forward ground speed specified in **Section 2 – Vehicle Specifications.**
5. If adjustment is necessary, use the following procedures:
 - 5.1. To **reduce** RPM, adjust the two jam nuts (6) to move the accelerator cable housing toward the rear of the vehicle until specified ground speed is reached (**Figure 5-6, Page 5-6**). **See Section 2 – Vehicle Specifications.**
 - 5.2. To **increase** RPM, adjust the two jam nuts to move the accelerator cable housing forward until specified ground speed is reached.
 - 5.3. Be sure both jam nuts are locked against the underbody and check ground speed again. If ground speed needs to be adjusted, repeat previous step. **See following NOTE.**

NOTE: If more adjustment is required than the cable housing will allow, make sure the spring fitting on the other end of the accelerator cable is properly installed. Excessive drive belt and clutch wear can also prevent proper ground speed adjustment. Check them for excessive wear. **Section 24 — Kohler ECH440 - Clutches**

AIR INTAKE SYSTEM

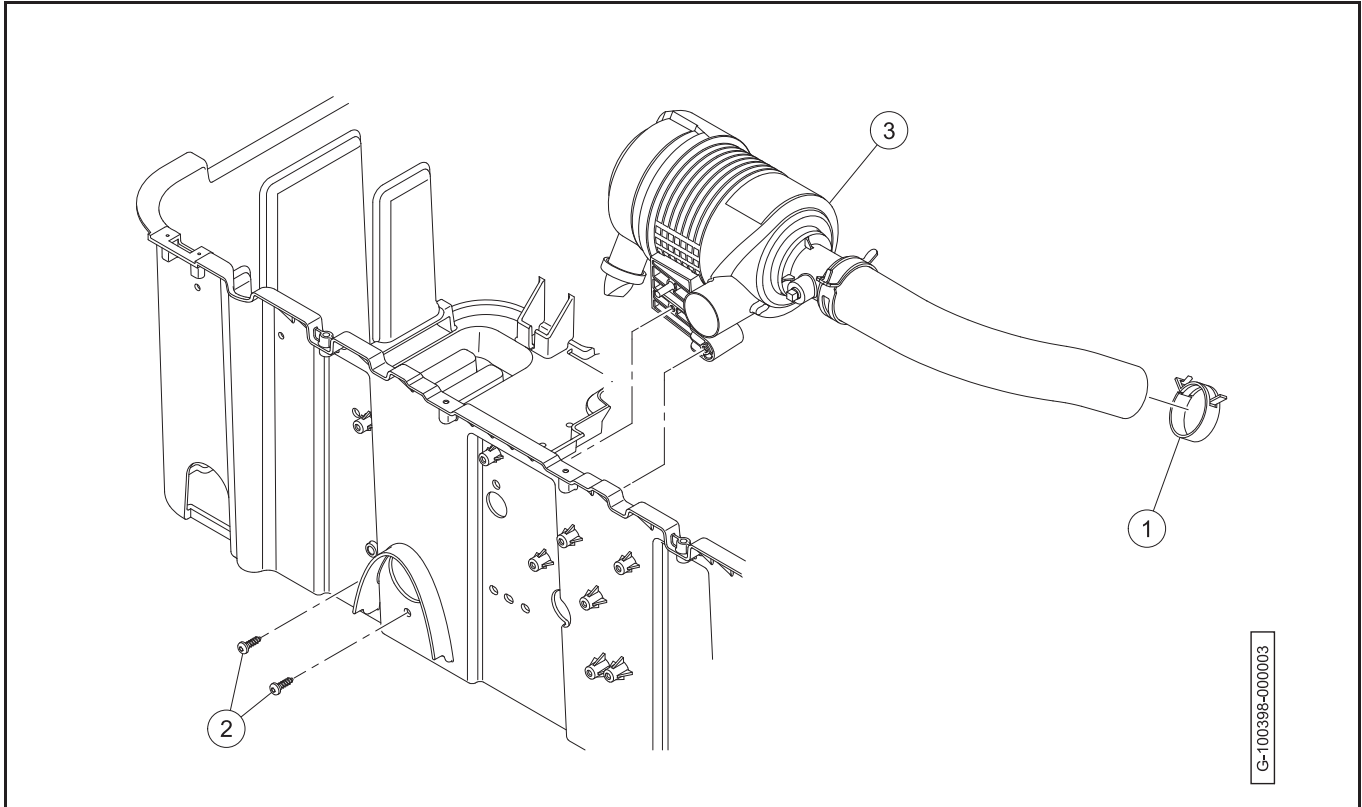


Figure 22-10 Air Intake System

AIR CLEANER REMOVAL

1. Disable the vehicle.
2. Disconnect battery and spark plug wire.
3. Loosen the clamp (1) and disconnect air intake hose from throttle body (**Figure 22-10, Page 22-10**).
4. Remove the screws (2).
5. Remove the air intake system (3).

AIR CLEANER INSTALLATION

1. Install the air intake system (3) into the vehicle (**Figure 22-10, Page 22-10**).
2. Install the screws (2). Tighten the screws to 85 in·lb (9.5 N·m).
3. Connect the air intake hose to the throttle body.
4. Install the clamp (1).
5. Connect the battery and spark plug wire.

RELIEVING FUEL PRESSURE

In the event that servicing the EFI fuel system necessitates removal of the fuel delivery hose, extreme caution must be exercised. The fuel system is under high pressure even with the engine not running. Disconnecting any part of the fuel delivery system, without first depressurizing the system, will result in a sudden release of pressurized gasoline at the connection. To prevent possible serious injury or death, fuel pressure must be relieved before disconnecting or removing the pump, hose and throttle body.

Either of these suggested procedures **MUST** be followed before attempting ANY service work on the EFI fuel system. Following these will relieve any pressure in the fuel hose prior to opening the fuel system.

TO RELIEVE FUEL PRESSURE

Option 1:

1. Turn the key switch to OFF.
2. Disconnect the battery.
3. Wait 15 minutes or more to let the fuel pressure dissipate.

Option 2:

1. Turn the key switch to OFF.
2. Disconnect the fuel pump module at the fuel tank.
3. Crank the engine for 5 seconds to start reducing the fuel pressure.
4. Wait for 2-5 seconds.
5. Crank the engine for 5 seconds to let the fuel pressure dissipate.

NOTE: To absorb any residual fuel that may be present in the fuel hose, place a rag or towel around the hose at the end being disconnected.

CARBON CANISTER

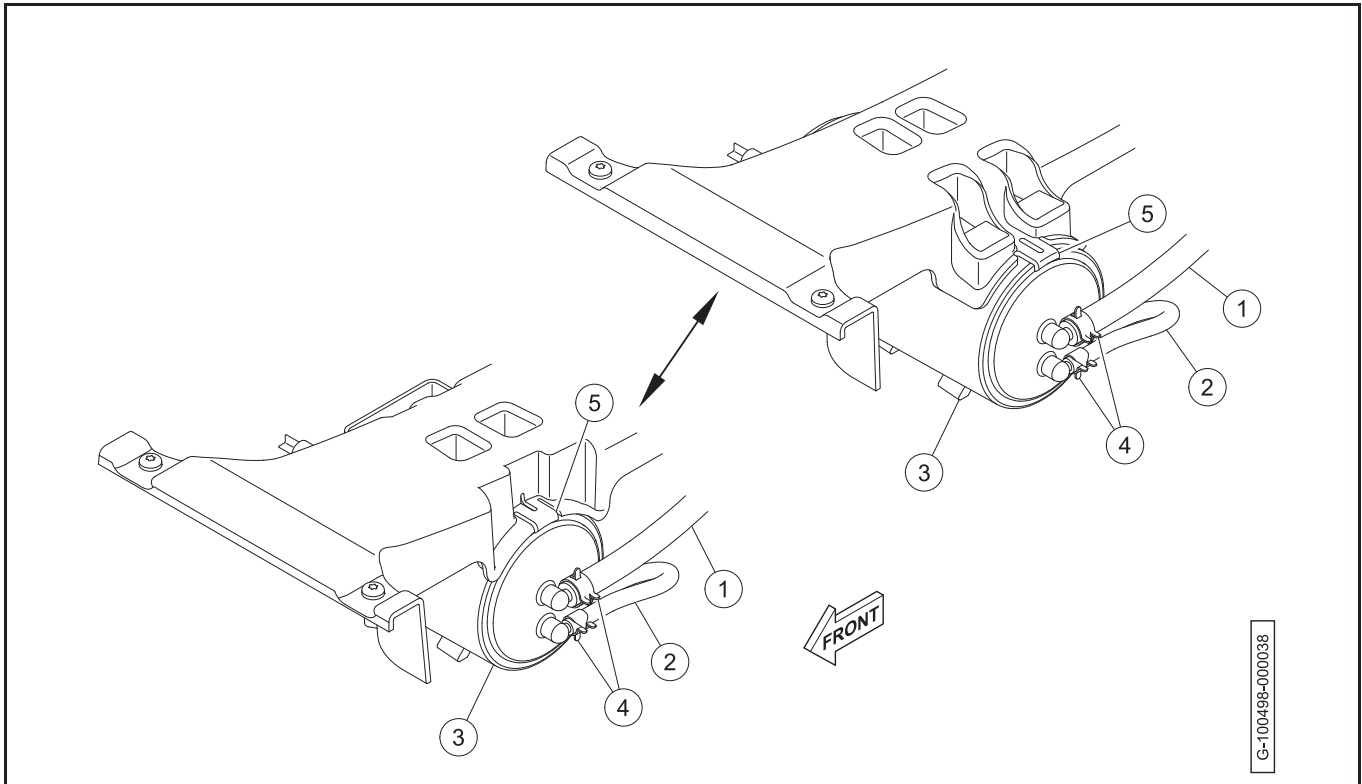


Figure 22-11

CARBON CANISTER REMOVAL

1. Disable the vehicle.
2. Relieve the fuel pressure.
3. Disconnect the battery.
4. Clean the area around the vent line (1) and purge line (2) on the carbon canister (3).
5. Remove the clamps (4).
6. Disconnect the vent line and purge line.
7. Remove the carbon canister from the bucket brace.
 - 7.1. Lift the tab (5).
 - 7.2. Slide the carbon canister towards the fuel tank and remove from the bucket brace.

CARBON CANISTER INSTALLATION

1. Install the carbon canister (3) on the bucket brace. Make sure that the tab (5) is secured (**Figure 22-11**).
2. Connect the vent line (1).
3. Connect the purge line (2).
4. Install the clamps (4).

FUEL LINE

⚠ WARNING

- Make sure that the fuel line is the correct length and properly routed. Failure to heed this warning could result in damage to fuel line and fire.
- Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure.

CAUTION

- This EFI gasoline vehicle is equipped with fuel hose rated for high-pressure systems. Always replace the fuel line on this vehicle with approved Club Car replacement part. Do not attempt to repair, patch or splice the fuel line.

The fuel line must be properly routed from the fuel tank to the throttle body. The fuel line has dual-locking connectors at both ends.

FUEL LINE REMOVAL

⚠ WARNING

- Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure.
- Carefully drain any fuel into an approved container. Add drained fuel back into fuel tank or dispose of properly.

1. Disable the vehicle.

⚠ WARNING

- Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure.

2. Relieve the fuel pressure.
3. Disconnect the battery.
4. Clean the top of the fuel tank and fuel pump module.

5. At engine:

- 5.1. Remove the bolt (1), washer (2), and P-clamp (3) from the fuel line support bracket (4) (**Figure 22-12, Page 22-14**).

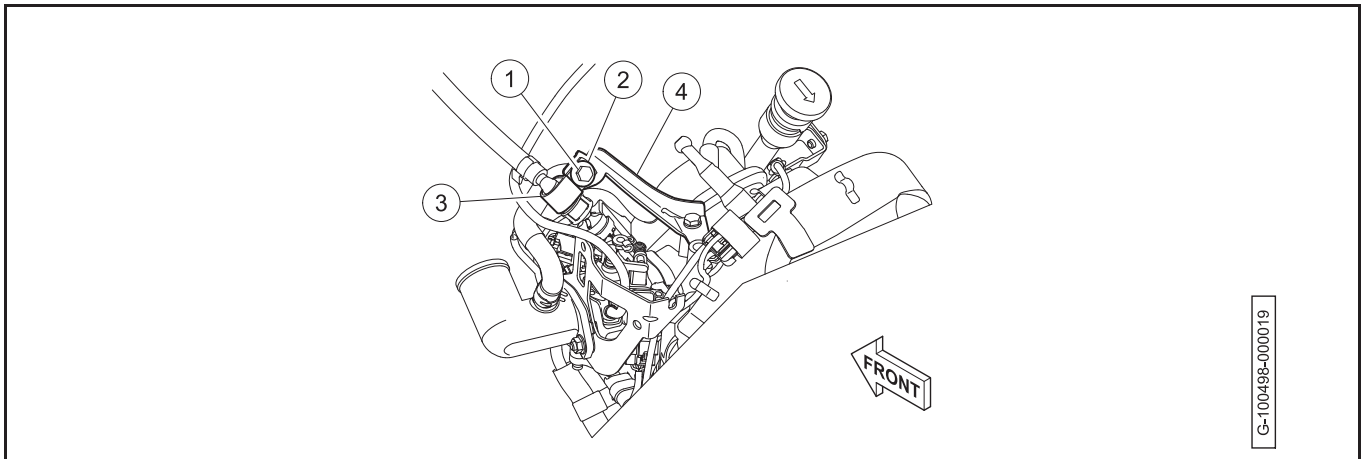


Figure 22-12

- 5.2. Pull out the locking clip (4) (**Figure 22-13, Page 22-14**).

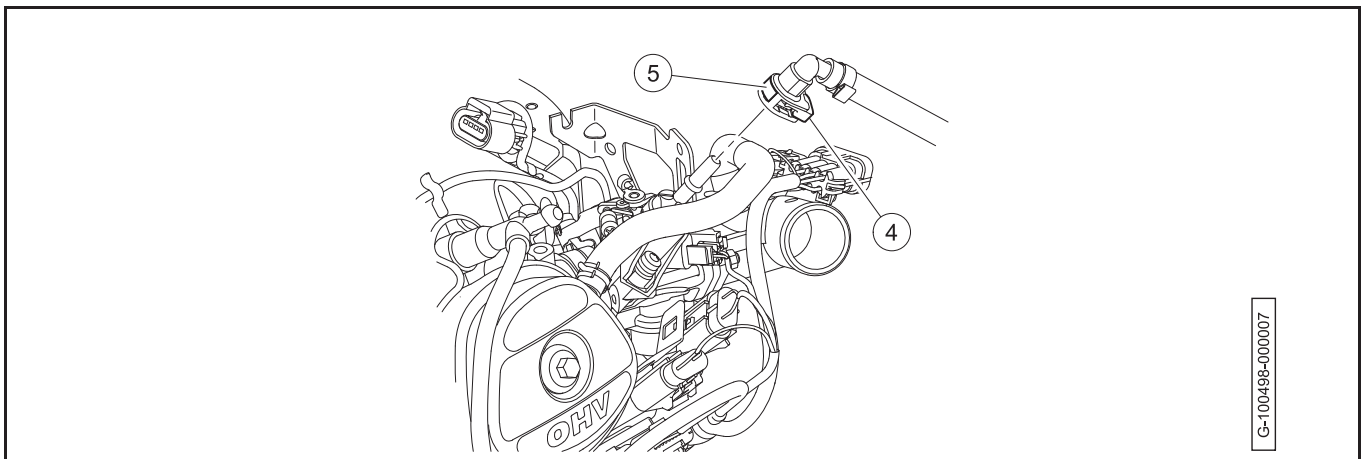


Figure 22-13

- 5.3. Push in and hold the release tab (5).
5.4. Remove the fuel line from the throttle body.
5.5. Drain the fuel line into an appropriate container.
6. At fuel tank:
- 6.1. Pull out the locking clip.
6.2. Push in and hold the release tab.
6.3. Remove the fuel line from fuel tank.

FUEL LINE INSTALLATION

1. Clean the nipple on the throttle body.

⚠ DANGER

- Make sure that the fuel line is connected properly to avoid a leak that can cause a fire.

2. Push the fuel line (1) onto the nipple until it locks into place (**Figure 22-14**).

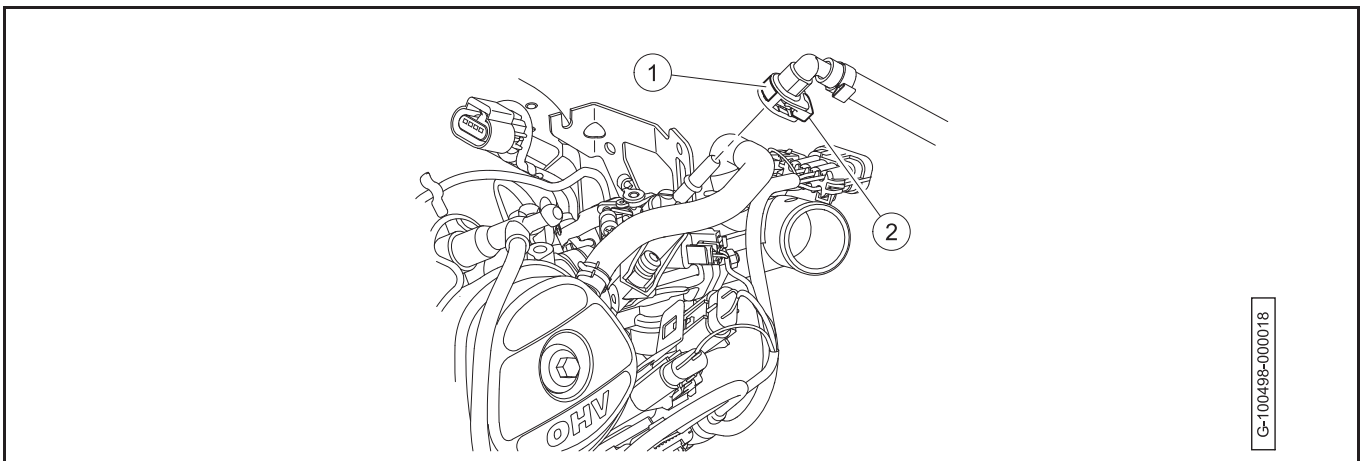


Figure 22-14

3. Push in the locking clip (2) until it is fully seated.
4. Make sure that the fuel line is $8^\circ (\pm 5^\circ)$ toward the fuel tank from the bucket brace (**Figure 22-15**).

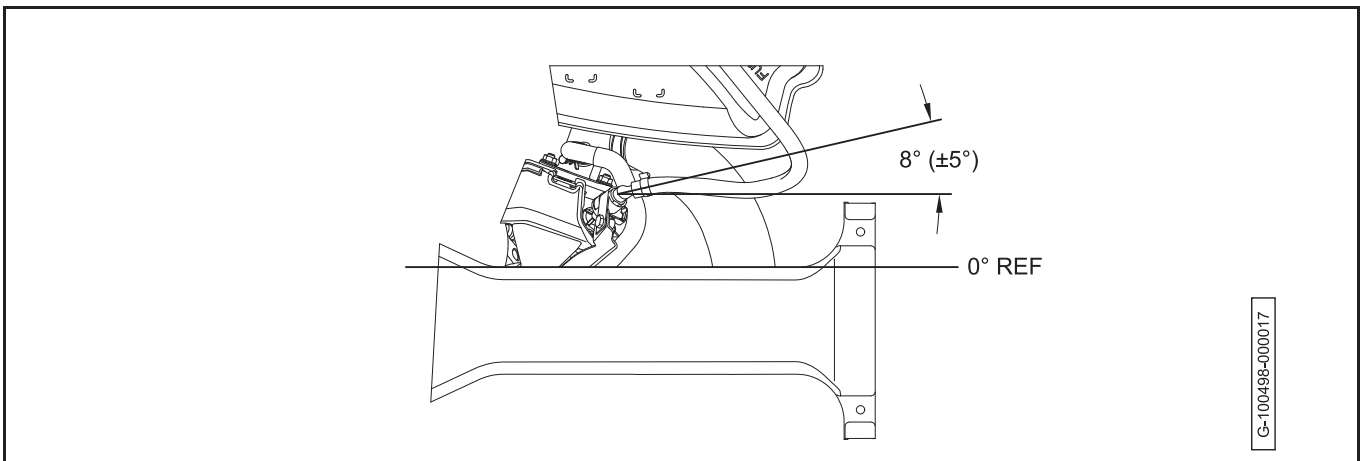


Figure 22-15

5. Install the P-clamp (1), washer (2), and bolt (3) onto the fuel line support bracket (4) (Figure 22-16). Tighten the bolt to 93 to 111 in·lb (10.5 to 12.5 N·m).

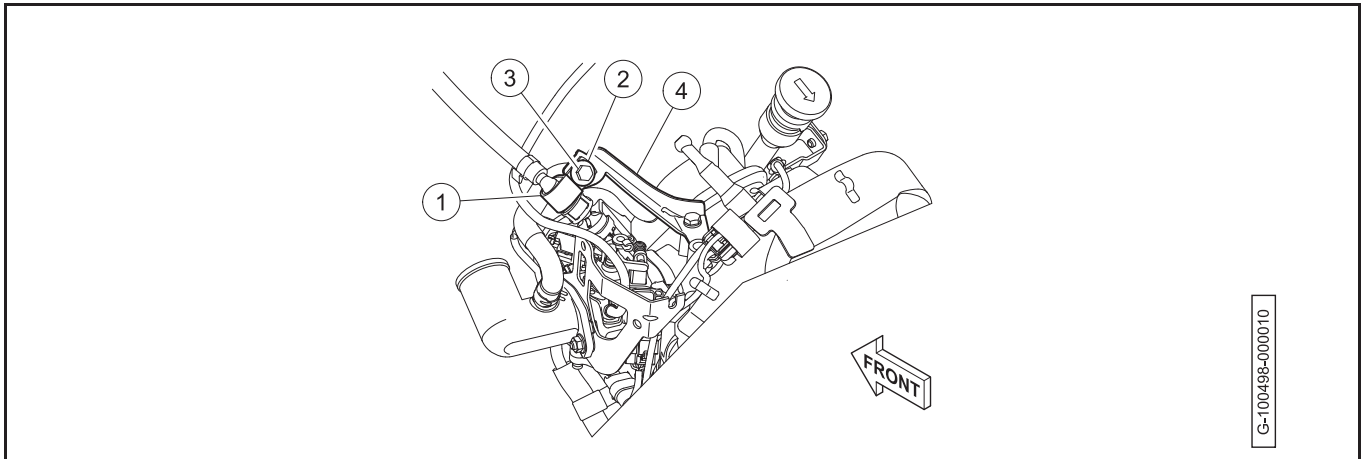


Figure 22-16

6. Clean the nipple on top of fuel pump module.
7. Rotate the fuel line connector (1) 180 degrees and connect it to the nipple (Figure 22-17, Page 22-16).

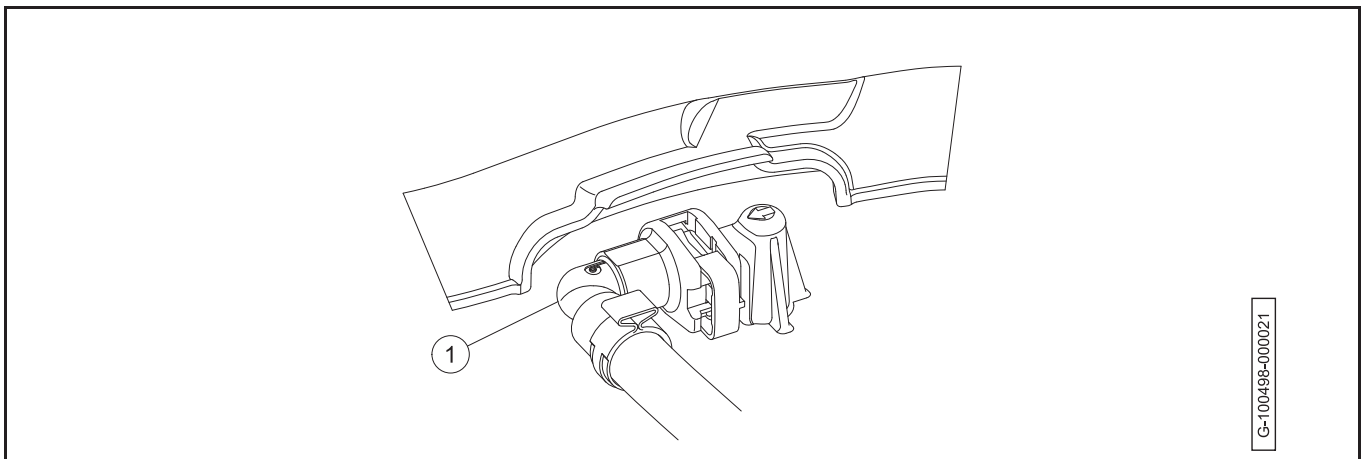


Figure 22-17

8. Push the fuel line until it locks into place.
9. Push in the locking clip until it is fully seated.

⚠ DANGER

- Make sure that the fuel line is connected properly to avoid a leak that can cause a fire.
- Make sure fuel line is the correct length and properly routed. Failure to heed this warning could result in damage to fuel line and fire.

10. Make sure that the fuel line is routed correctly (Figure 22-18).

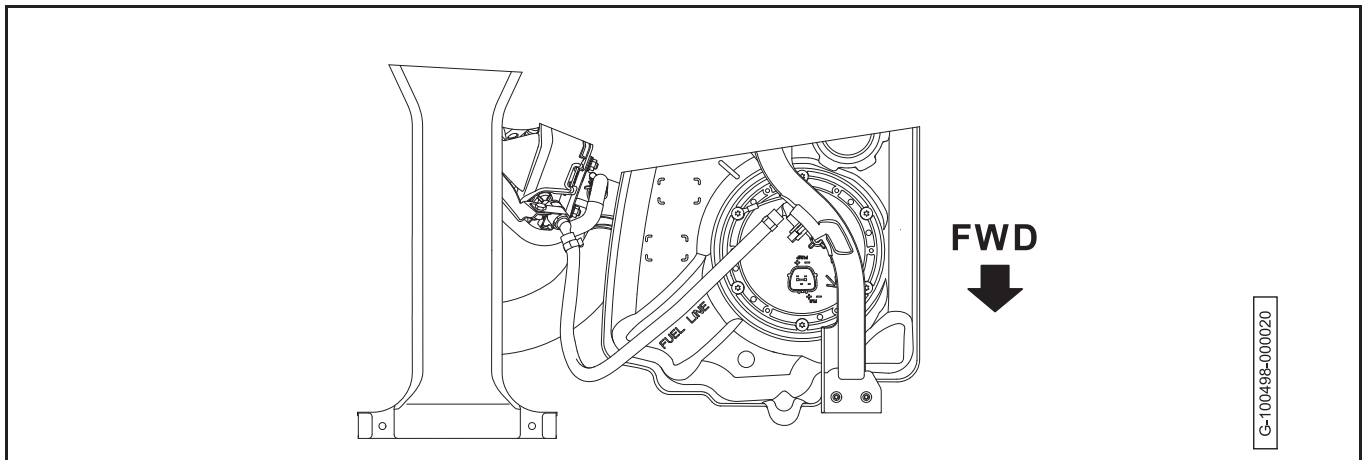


Figure 22-18

11. Clean spilled and remove any drained gasoline from the area.
12. Connect the battery.
13. Disable the vehicle.
14. Set the Maintenance/Operate switch to MAINTENANCE.
15. Turn the key switch to the ON position and check for fuel leaks. Repeat as necessary to build fuel pressure. Any leaks found must be fixed.

⚠ DANGER

- Repair all fuel leaks before returning the vehicle to service.

16. If no leaks are found, set the Maintenance/Operate switch in the OPERATE.

FUEL PUMP MODULE

GENERAL INFORMATION

NOTE: The fuel pump and fuel level sending unit themselves are not replaceable. If necessary, the fuel pump module must be replaced as an assembly.

The fuel pump module can be disassembled to replace the fuel filter.

NOTE: Fuel pump replacement kits will include a fuel level sending unit.

The EFI gasoline vehicle is equipped with an electric fuel pump. The fuel pump is protected by a filter and pickup screen.

FUEL PUMP MODULE REMOVAL

1. Disable the vehicle.

2. Disconnect the battery.
3. Clean the top of the fuel tank and fuel pump module.
4. With a marker pen, make a mark across the top of the fuel pump module and onto the tank to note orientation before removal.
5. Remove the screws (1) (**Figure 22-19, Page 22-18**).

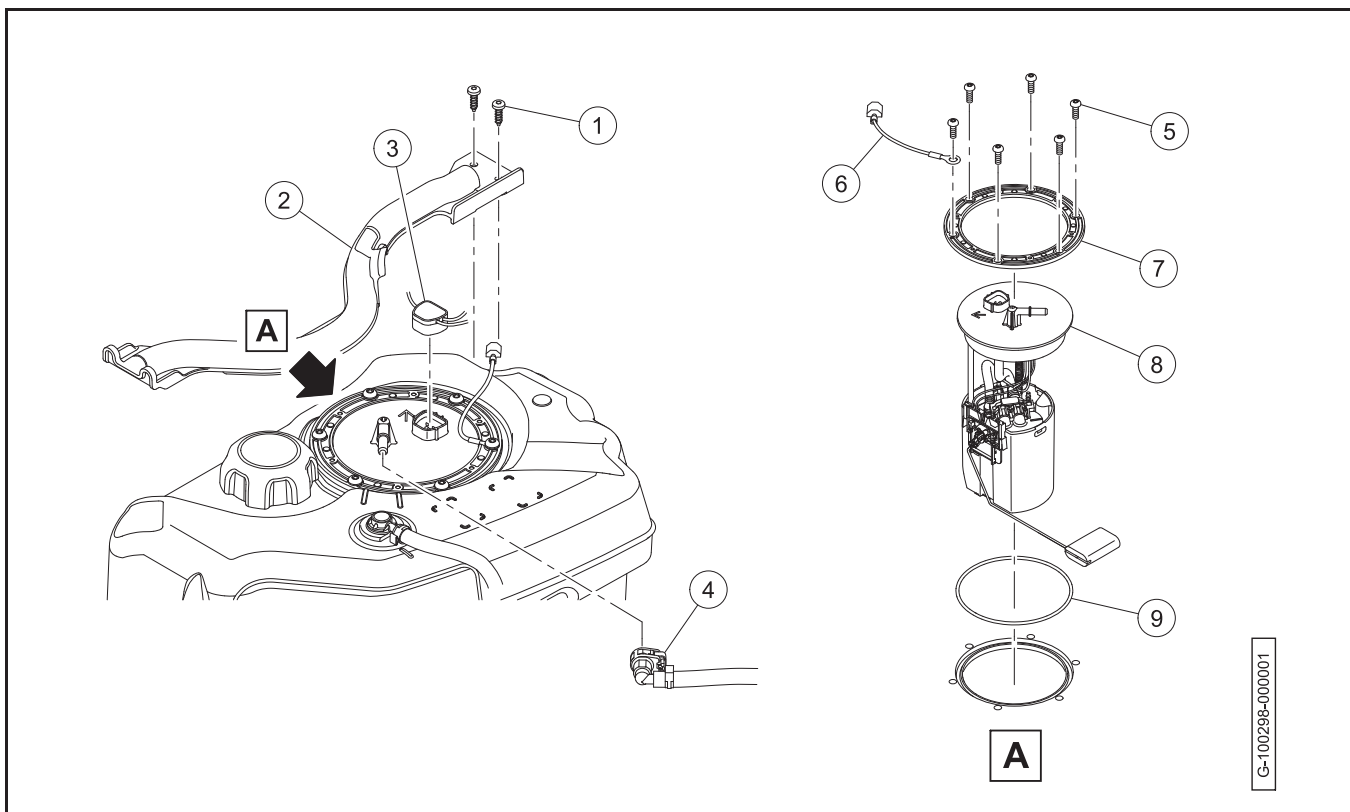


Figure 22-19 Fuel Pump Module Removal

6. Remove the fuel tank retaining strap (2).
7. Disconnect the wire harness from the fuel pump module plug (3).

⚠ WARNING

- Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure.
- Carefully drain any fuel remaining in the hose or pump module into an approved container. Add drained fuel back into fuel tank or dispose of properly.

8. Disconnect the fuel line (4) and drain into an appropriate container. See Fuel Line Removal.
9. Remove the screws (5).
10. Remove the ground wire (6) and hold down ring (7).
11. Lift the fuel pump module (8) out of fuel tank and drain into an appropriate container.

NOTE: If equipped with a fuel level sending unit, carefully maneuver module so as to avoid damaging the float arm mechanism.

12. Discard the fuel module o-ring (9).

FUEL PUMP MODULE INSTALLATION

1. Clean the groove on top of fuel tank.
2. Install the new fuel module o-ring (9) into groove on top of fuel tank (**Figure 22-20, Page 22-19**).

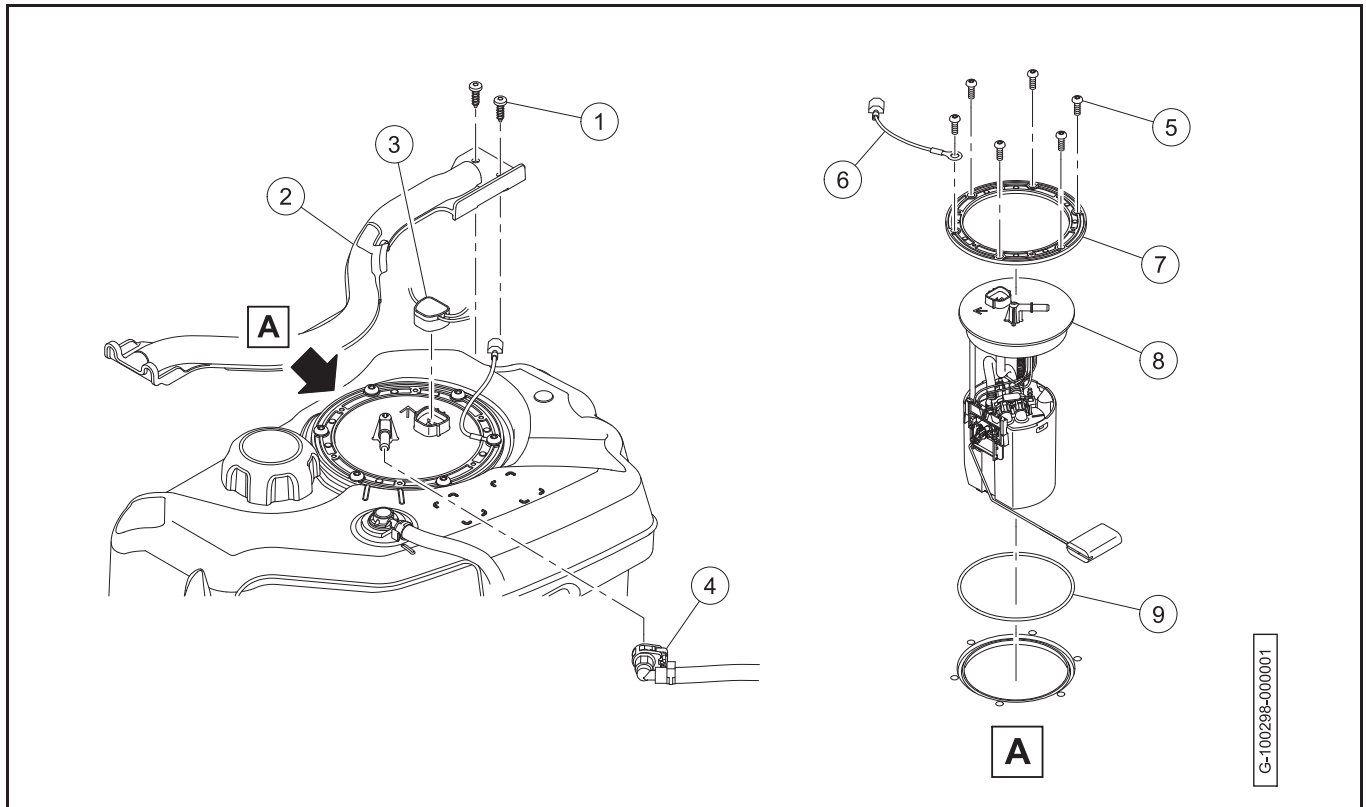


Figure 22-20 Fuel Pump Module Installation

3. Lower the fuel pump module (8) into fuel tank noting correct orientation marked before removal. **See following NOTE and CAUTION.**

NOTE: If equipped with a fuel level sending unit, carefully maneuver module so as to avoid damaging the float arm mechanism.

⚠ CAUTION

- Ensure o-ring stays seated in place during fuel pump module installation.

4. Install the hold down ring (7)
5. Install the ground wire (6) and screws (5). **See following WARNING.** Tighten the screws in a crisscross pattern to 66 in·lb (7.5 N·m).

⚠ WARNING

- Always install ground wires during reassembly.

6. Connect the fuel line (4) to fuel pump module. See Fuel Line Installation. **See following DANGER.**

DANGER

- Ensure line is connected properly to avoid a leak that can cause a fire.

7. Connect the wire harness to the fuel pump module plug (3).
8. Install the fuel tank retaining strap (2).
9. Install the screws (1). Tighten the screws to 31 in·lb (3.5 N·m).
10. Clean spilled fuel. Remove any drained fuel from the area.
11. Connect the battery.
12. Disable the vehicle.
13. Set the Maintenance/Operate switch to MAINTENANCE.
14. Turn the key switch to ON and check for fuel leaks. Repeat as necessary to build fuel pressure. Any leaks found must be fixed.

DANGER

- Repair all fuel leaks before returning the vehicle to service.

15. If no leaks are found, set the Maintenance/Operate switch to OPERATE.

FUEL TANK

GENERAL INFORMATION

The vehicle is equipped with a high impact, plastic fuel tank.

WARNING

- If the fuel tank is damaged, replace it. Do not attempt to repair it. See the following tank removal and disposal procedure.

CAUTION

- Add only unleaded fuel to the tank. Do not put oil in the fuel tank.

NOTE: This gasoline vehicle complies with the California Air Resources Board (CARB) and EPA evaporative emissions regulations when equipped with SAEJ30R9 1/4 in (6.3 mm) fuel vent hose and 3/16 in (4.78 mm) fuel vent hose. To remain in compliance with California and EPA regulations, replace any fuel vent hose on this vehicle with Club Car fuel vent hoses or equivalent.

FUEL TANK REMOVAL

1. Disable the vehicle.
2. Set the Maintenance/Operate switch to MAINTENANCE.
3. Disconnect the battery.
4. Clean the top of the fuel tank and fuel pump module.

5. Remove gas cap and siphon all fuel from tank into an approved container. **See following DANGER and WARNING.**

⚠ DANGER

- Gasoline – Flammable! Explosive! Do not smoke. Keep sparks and flames away from the vehicle and service area. Service only in a well-ventilated area.

⚠ WARNING

- Do not attempt to siphon fuel using a hose that does not have a built-in suction device.
 - Do not attempt to siphon fuel using your mouth.
6. Disconnect the wire harness (1) from the fuel pump module (**Figure 22-21, Page 22-21**).

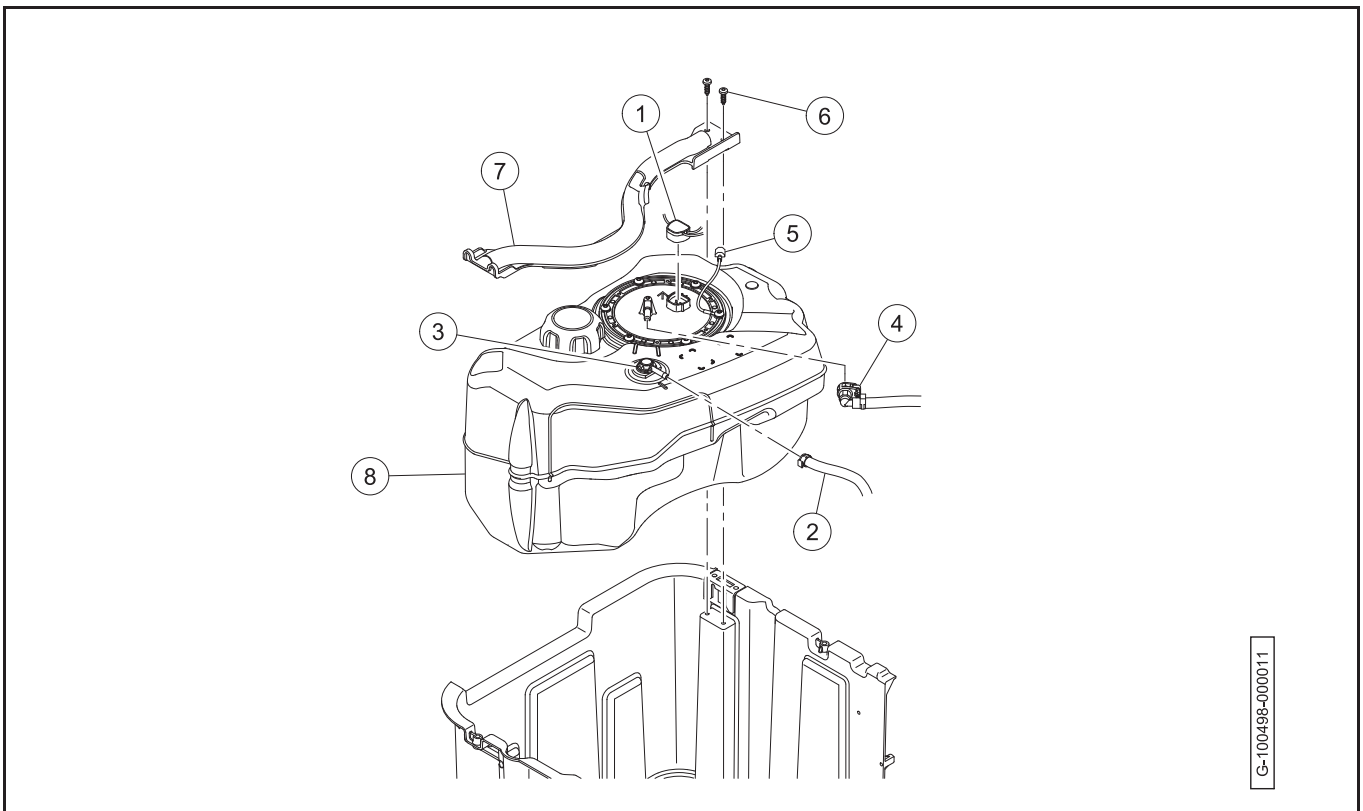


Figure 22-21 Fuel Tank Removal

7. Disconnect the vent hose (2) from fuel tank vent (3).
8. Disconnect the fuel line (4) from the fuel pump module and drain into an appropriate container. **See Fuel Line Removal. See following WARNING.**

⚠ WARNING

- Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure.
 - Carefully drain any fuel remaining in the hose or pump module into an approved container. Add drained fuel back into fuel tank or dispose of properly.
9. Disconnect fuel pump module ground wire (5).
 10. Remove the screws (6).
 11. Remove the fuel tank retaining strap (7).
 12. Remove the fuel tank (8).

FUEL TANK DISPOSAL

1. Remove gas cap and fuel pump module from tank. See Fuel Pump Module Removal. The cap may be discarded or kept as a spare.
2. In a well-ventilated area, flush the fuel tank with water to remove any remaining fuel.
3. In a well-ventilated area, set the tank upside down so that the water can drain out of it. To make sure that the tank dries completely, allow the tank to sit for 24 hours. **See following CAUTION.**

⚠ CAUTION

- Dispose of wastewater and fuel tank in accordance with local, state, and federal laws and ordinances.

FUEL TANK STORAGE

1. Remove gas cap and fuel pump module from tank. See Fuel Pump Module Removal.
2. In a well-ventilated area, flush the fuel tank with water to remove any remaining fuel.
3. In a well-ventilated area, set the tank upside down so that the water can drain out of it. To make sure that the tank dries completely, allow the tank to sit for 24 hours.
4. Completely drain gas from fuel pump module and allow to module to dry.
5. After the module is completely dry, install it in fuel tank. See Fuel Pump Module Installation.
6. Store the tank upside down, with the cap installed, in a well-ventilated area.

FUEL TANK INSTALLATION

NOTE: This gasoline vehicle complies with the California Air Resources Board (CARB) and EPA evaporative emissions regulations when equipped with SAEJ30R9 1/4 in (6.3 mm) fuel vent hose and 3/16 in (4.78 mm) fuel vent hose. To remain in compliance with California and EPA regulations, replace any fuel vent hose on this vehicle with Club Car fuel vent hoses or equivalent.

1. Install the fuel tank (8) in vehicle (**Figure 22-22, Page 22-23**).

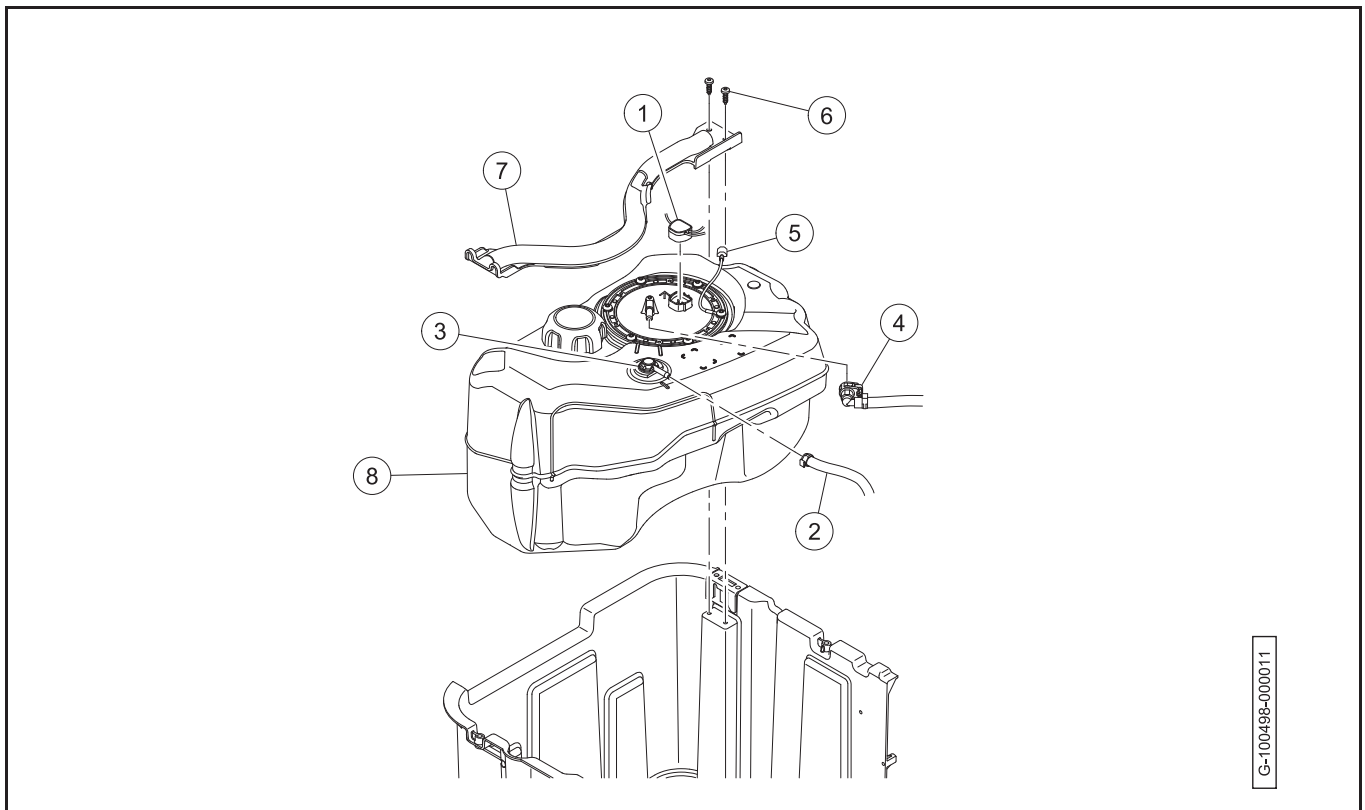


Figure 22-22 Fuel Tank Installation

2. Install the fuel tank retaining strap (7).
- 2.1. Insert the tabs on the rear of the fuel tank retaining strap into the slots on the back of the bucket.
- 2.2. Align the front of the fuel tank retaining strap with the mounting holes on the bucket.
- 2.3. Install the screws (6). Tighten the screws to 31 in·lb (3.5 N·m).
3. Connect the ground wire (5) to main wire harness. **See following WARNING.**

⚠ WARNING

- Always install ground wires during reassembly.

4. Connect the fuel line (4) to the fuel pump module. **See following DANGER.**

⚠ DANGER

- Ensure line is connected properly to avoid a leak that can cause a fire.

5. Install the vent line (2) onto the fuel tank vent (3).
6. Connect the wire harness (1) to fuel pump module.
7. Clean spilled fuel and remove any drained fuel from the area.
8. Connect the battery.
9. Add fuel to the fuel tank.
10. Disable the vehicle.
11. Set the Maintenance/Operate switch to MAINTENANCE.

12. Turn key switch to the ON position and check for fuel leaks. Repeat as necessary to build fuel pressure. Any leaks found must be fixed.

DANGER

- Repair all fuel leaks before returning the vehicle to service.

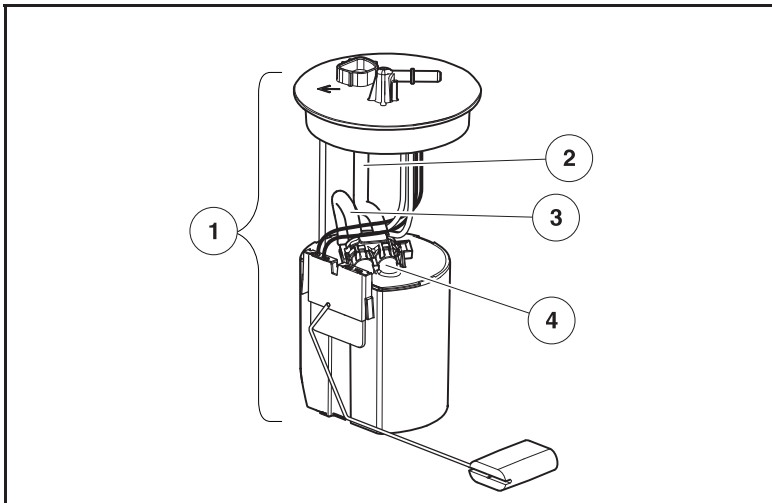
13. If no leaks are found, set the Maintenance/Operate switch to OPERATE.

FUEL FILTER

GENERAL INFORMATION

The fuel filter is located in the fuel tank. It is part of the fuel pump module assembly and should last the life of the vehicle; however, it is replaceable if the need should arise. In addition, the module assembly features a fuel pickup screen to catch larger particles before entering the fuel filter.

FUEL FILTER REMOVAL



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Figure 22-23 Fuel Filter Removal

1. Disable the vehicle.
2. Disconnect the battery.
3. Remove fuel pump module (1) (**Figure 22-23, Page 22-24**). See Fuel Pump Module Removal.
4. Disconnect the flex hoses (2 and 3) from filter (4).
 - 4.1. Pull the hose retainer clip straight up and out of the filter. Do not discard clip.
 - 4.2. Pull the flex hoses straight out of the filter inlet and outlet.
5. Remove filter from fuel pump module and dispose of properly.

FUEL FILTER INSTALLATION

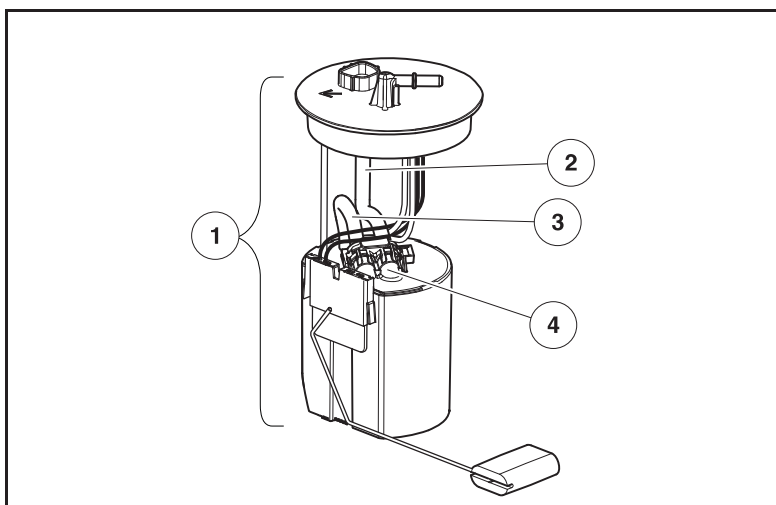
⚠ CAUTION

- Fuel filter flex hoses are keyed to aid proper installation into fuel pump module.

NOTE: The fuel filter is keyed to the fuel pump module to prevent incorrect assembly.

The inlet and outlet flex hoses are keyed to the fuel filter ports to prevent incorrect assembly.

1. Orient fuel filter (4) and insert into fuel pump module (1) until fully seated (**Figure 22-24, Page 22-25**).



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Figure 22-24 Fuel Filter Installation

2. Connect flex hoses (2 and 3) to the fuel filter.
 - 2.1. Orient flex hoses with matching port in filter and push each hose end straight into filter until fully seated.
 - 2.2. Push hose retainer clip straight into filter until fully seated.
3. Install fuel pump module. See Fuel Pump Module Installation.
4. Connect the battery and spark plug wire.
5. Set the Forward/Neutral/Reverse control (FNR) to N.
6. Chock the wheels.
7. Set the Maintenance/Operate switch to MAINTENANCE.
8. Start the engine and check for fuel leaks. **See following DANGER.**

⚠ DANGER

- Repair all fuel leaks before operating the vehicle.

9. If no leaks are found, set the Maintenance/Operate switch to OPERATE.

Pagination Page

⚠ DANGER

- See General Warnings on page 1-2.

⚠ WARNING

- See General Warnings on page 1-2.

MUFFLER

MUFFLER REMOVAL

1. Disconnect the battery and spark plug wire.
2. If necessary, remove the oxygen sensor (1) from the muffler (2) (Figure 23-1, Page 23-1). See Oxygen Sensor Removal.

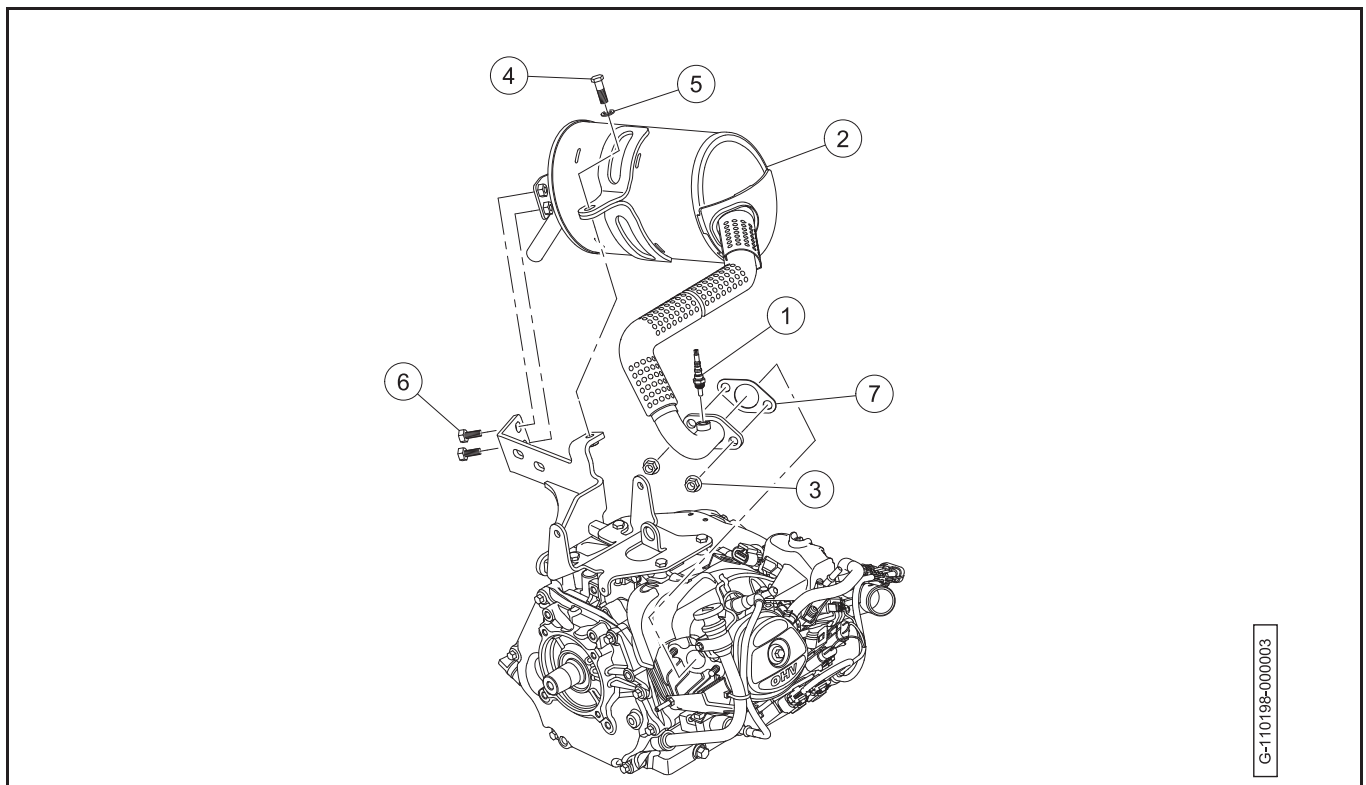


Figure 23-1 Muffler Removal

3. Remove the nuts (3).
4. Remove the bolt (4) and washer (5).
5. Remove the bolts (6).
6. Remove the muffler.
7. Remove the exhaust gasket (7).

MUFFLER INSTALLATION

1. Install the new exhaust gasket (7) on the exhaust port studs (Figure 23-2, Page 23-2).

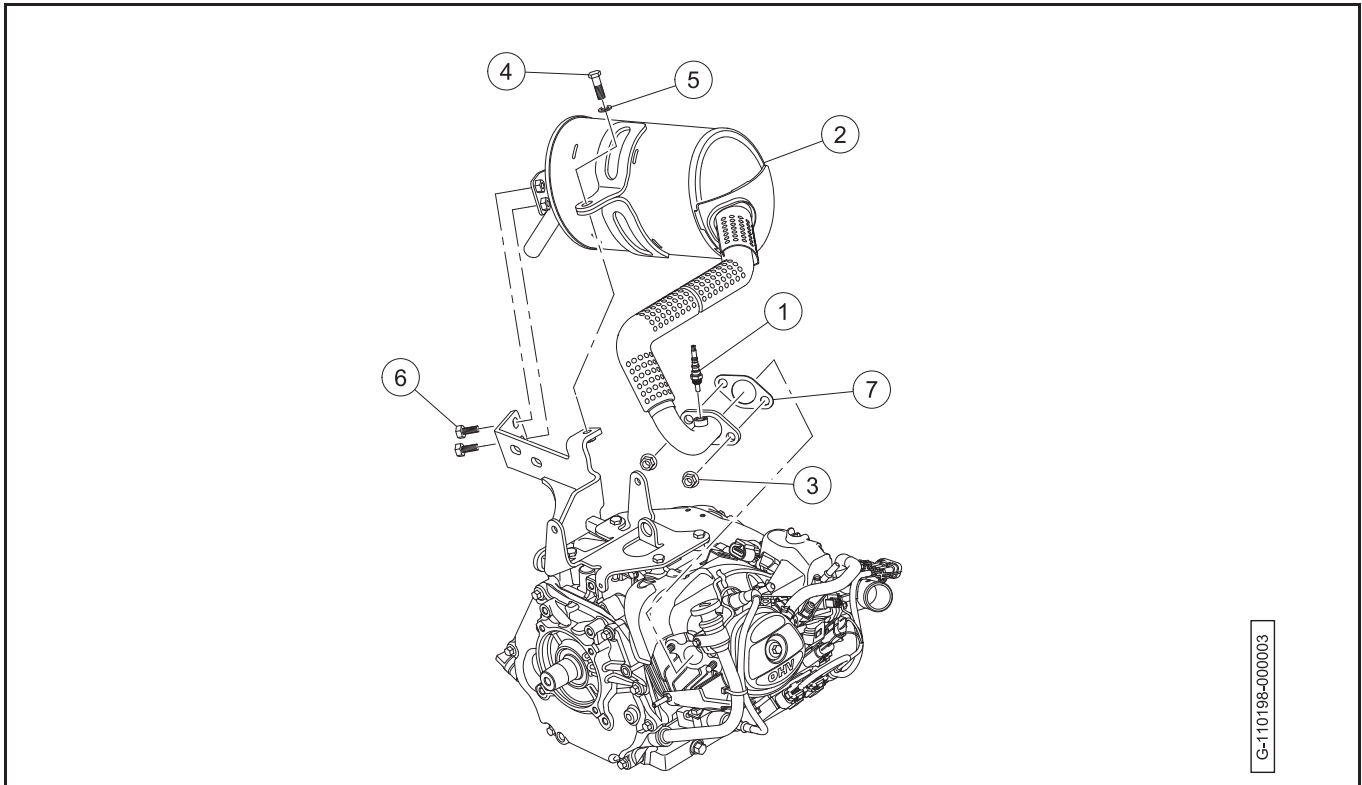


Figure 23-2 Muffler Installation

2. Put the muffler (2) into position on the engine.
3. Install the nuts (3), bolt (4), washer (5), and bolts (6). Tighten the hardware by hand.
4. Tighten the hardware in the following order:
 - 4.1. Tighten the nuts (3) to 19 ft·lb (26 N·m).
 - 4.2. Tighten the bolt (4) to 17 ft·lb (23 N·m).
 - 4.3. Tighten the bolts (6) to 17 ft·lb (23 N·m).
5. If the oxygen sensor (1) was removed, install the oxygen sensor. See Oxygen Sensor Installation.
6. Connect the battery and spark plug wire.
7. Set the Forward/Neutral/Reverse control (FNR) to N.
8. Set the Maintenance/Operate switch to MAINTENANCE.
9. Put the chocks against the wheels.

⚠ DANGER

- Do not operate gasoline vehicle in an enclosed area without proper ventilation. The engine produces carbon monoxide, which is an odorless, deadly poison.

10. Start the engine.
11. Check for exhaust leaks and correct engine operation. **See following DANGER.**

⚠ DANGER

- See General Warnings on page 1-2.

⚠ WARNING

- See General Warnings on page 1-2.

GENERAL INFORMATION

The torque converter consists of a drive clutch, a driven clutch, and a drive belt. The drive clutch, which is mounted to the engine, is in the open position when the engine is at idle. At this point, the belt is riding at a low position (smaller diameter) on the drive clutch. The driven clutch is mounted on the transaxle. It is in the closed position, and the drive belt is riding at a high position (large diameter) on it when the engine is at idle.

At the point of clutch engagement, the speed ratio of the drive clutch to the driven clutch provides excellent starting and low-speed torque.

As engine speed increases, centrifugal force on internal weights close the drive clutch, pushing the belt up to a higher position on the clutch (increasing the diameter of the belt loop). As the diameter of the belt loop increases at the drive clutch, the driven clutch is forced open as the diameter of its belt loop decreases.

On steep grades, or when the vehicle is heavily loaded, higher torques are achieved through the use of a torque-sensing ramp device on the driven clutch. This device overcomes the force of the centrifugal weights to close the driven clutch and open the drive clutch, thus increasing axle torque with little or no change in engine RPM.

The engine and torque converter rotate counter-clockwise as viewed from the clutch side of the engine.

To provide optimum performance for the engine and powertrain, the vehicle uses a pair of tuned clutches.

To properly assemble and disassemble the torque converter, the following tools should be used:

- Drive Clutch Hub Puller
- Drive Clutch Puller
- Drive Clutch Holder Tool
- Driven Clutch Cam Puller
- Driven Clutch Puller Plug
- Driven Clutch Cam Press
- Scribe or small pick (not included with clutch tools).

TROUBLESHOOTING

Maintaining proper adjustment of the engine and governor, as well as the torque converter, is essential to the troubleshooting process. If these adjustments are within specifications and, when climbing a steep hill, the engine begins to lose RPM before the drive belt reaches the top of the driven clutch, there is a torque converter problem.

If the torque converter is not operating properly, perform the following steps:

1. Check the governor and throttle settings. See Engine Control Linkages.
2. Inspect the driven clutch for dirt and dust buildup on its component parts. Clean the driven clutch with water to remove any dust or dirt, then drive the vehicle and check for proper operation.
3. If cleaning the driven clutch does not solve the problem, disassemble and thoroughly clean all parts of the drive clutch. Be sure to clean the plastic drive buttons (7) (**Figure 24-2, Page 24-4**).

DRIVE BELT

The drive belt should be inspected semiannually for wear and (or) glazing. If it is excessively worn, frayed, or glazed, replace the belt.

As the drive belt wears, the engine RPM will increase to compensate for the change in torque converter ratio. This will keep the vehicle's maximum ground speed correct. **See Vehicle Specifications.**

DRIVE BELT REMOVAL

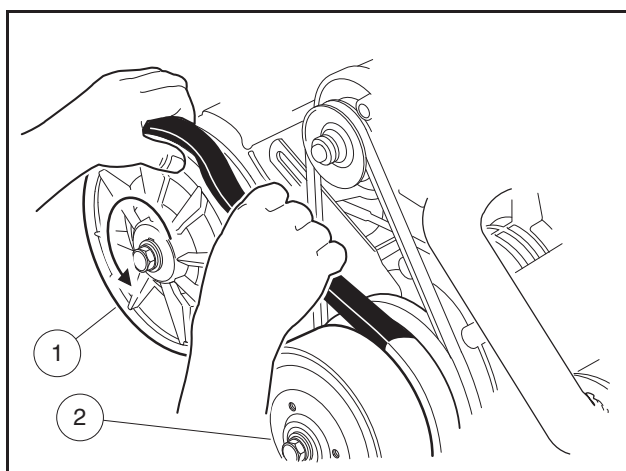
1. Disconnect battery and spark plug wire. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Grasp the belt midway between the drive (2) and driven (1) clutches. Lift upward on the belt to force the sheaves of the driven clutch (1) apart, then roll the belt off the driven clutch by rotating the clutch counterclockwise (**Figure 24-1, Page 24-3**). **See following CAUTION.**

⚠ CAUTION

- **Make sure fingers are not underneath the belt when rolling the belt off the driven clutch.**

NOTE: Roll away from compression to make removal easier.

3. Remove the belt from the drive clutch (2).



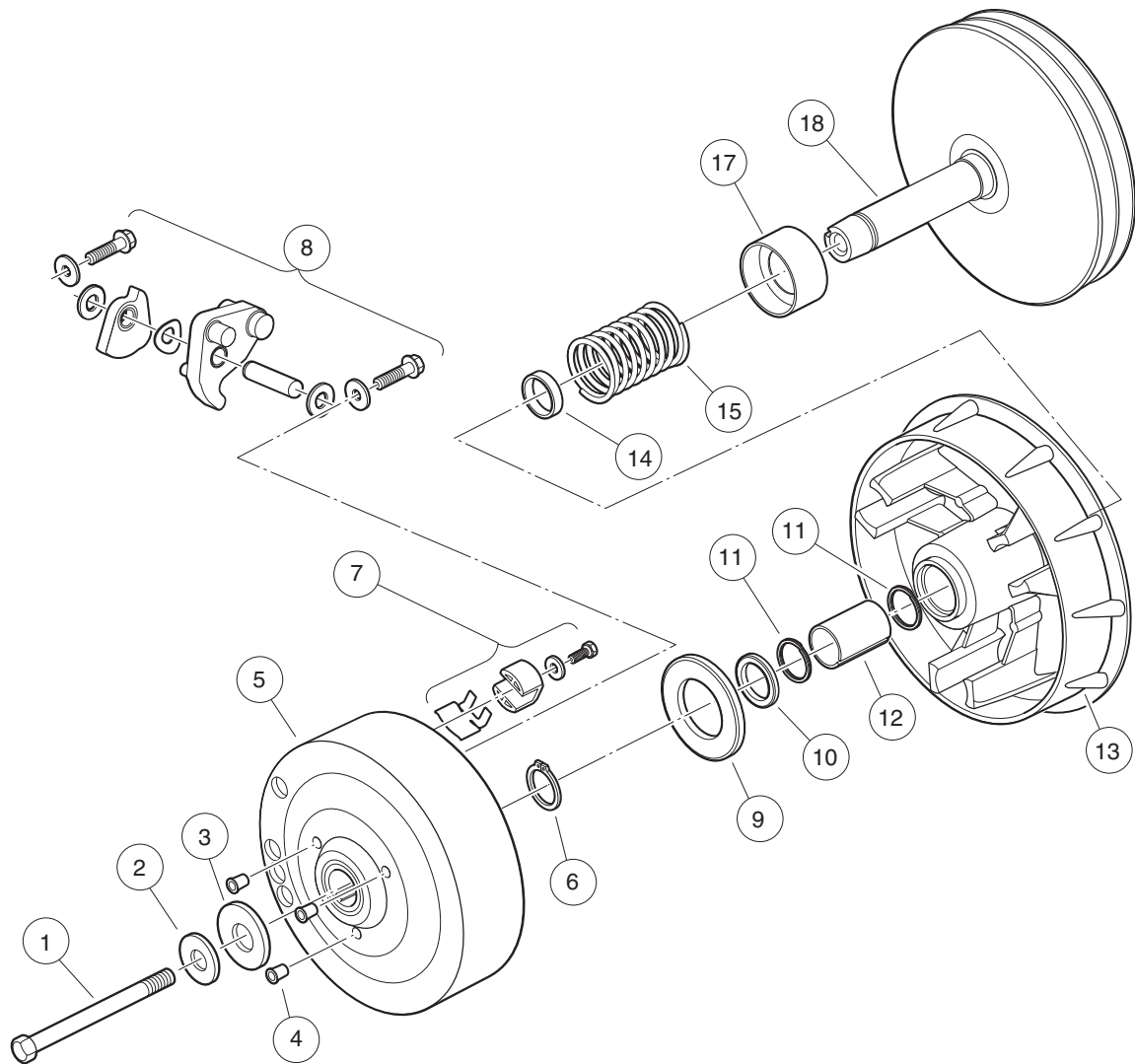
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Figure 24-1 Drive Belt Removal

DRIVE BELT INSTALLATION

1. Position the new belt on the drive clutch (2), then start the belt over the top of the driven clutch (1).
2. With the belt started onto the driven clutch (1), rotate the driven clutch counterclockwise and roll the belt over the outer, moveable sheave.
3. Connect battery and spark plug wire. **See Connect the Battery - Gasoline Vehicles on page 1-4.**

DRIVE CLUTCH



| | |
|---|----------------------------------|
| 1. Screw, 3/8-24 x 5.75, Patch | 10. Retainer |
| 2. Washer, Hard, M10 | 11. Ring, Spiral Backup |
| 3. Washer, 3/8, Type A, Flat | 12. Bushing, Split, Drive Clutch |
| 4. Cap Plug | 13. Sheave, Moveable, Drive |
| 5. Drive Hub Assy, Drive Clutch | 14. Spacer, Fixed Face Shaft |
| 6. Ring, 0.810 in. (20.5 mm) Internal Retaining | 15. Spring, Drive Clutch |
| 7. Drive Clutch Button | 16. No Item to Show |
| 8. Drive Clutch Weight | 17. Spacer, Idler, Drive |
| 9. Thrust Washer | 18. Sheave, Fixed, Drive |

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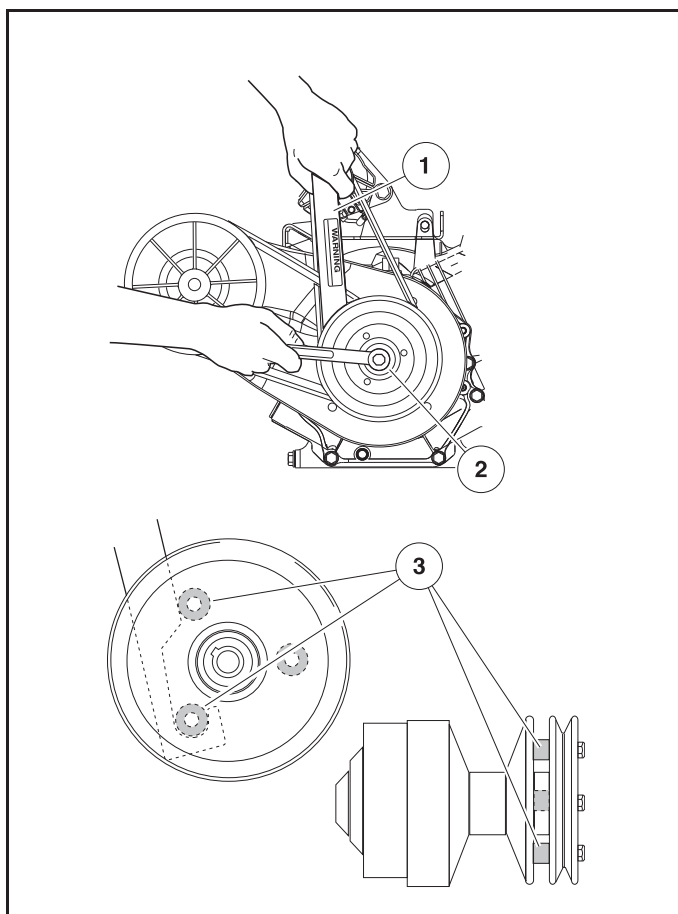
Figure 24-2 Drive Clutch – Exploded View

⚠ CAUTION

- Be very careful when handling the clutches. A clutch that has been dropped will not be properly balanced. If either clutch is dropped, assume that it is damaged and replace it.

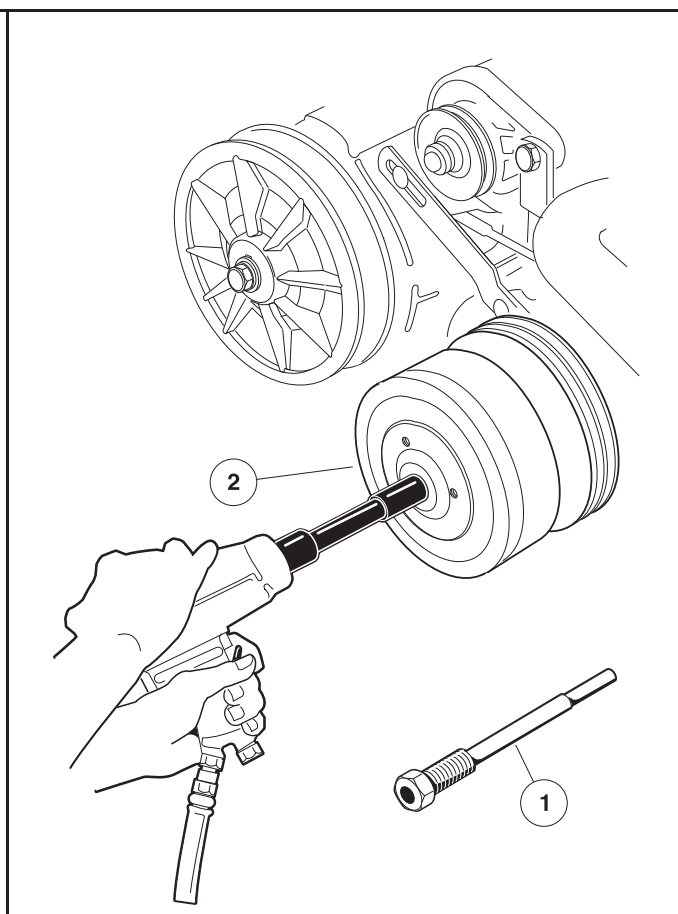
DRIVE CLUTCH REMOVAL

1. Remove the drive belt as instructed. **See Drive Belt Removal on page 24-3.**
2. Loosen starter/generator mounting and adjusting hardware and remove starter belt. **See WARNING “Moving parts! Do not...” in .**



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Figure 24-3 Loosen Retaining Bolt



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Figure 24-4 Drive Clutch Removal

3. Place chocks at the front wheels and lift the rear of the vehicle with a chain hoist or floor jack. Place jack stands under the chassis to support the vehicle. The weight of the powertrain will allow the centerline of the drive clutch to drop below the frame I-beam for access to the bolt securing the drive clutch. **See following WARNING.**

⚠ WARNING

- Lift only one end of the vehicle at a time. Use a suitable lifting device (chain hoist or hydraulic floor jack) with 1000 lb. (454 kg) minimum lifting capacity. Do not use lifting device to hold vehicle in raised

WARNING CONTINUED ON NEXT PAGE

⚠ WARNING

position. Use approved jack stands of proper weight capacity to support the vehicle and chock the wheels that remain on the floor. When not performing a test or service procedure that requires movement of the wheels, lock the brakes.

4. Remove the drive clutch retaining bolt (1) and mounting washers (2 and 3) (Figure 24-2, Page 24-4). See also Figure 24-3, Page 24-5. See following NOTE.

NOTE: The drive clutch mounting bolt has right-hand threads.

The crankshaft has right-hand threads at the clutch mounting hole.

- 4.1. Use the drive clutch holder tool (1) while tightening or loosening the drive clutch retaining bolt (2) (Figure 24-3, Page 24-5).
- 4.2. Hook clutch holder on boss (3) of pulley located behind drive clutch and push against the adjacent boss with holder.
5. Lubricate the threaded portion of the clutch puller tool (1) with a light oil and thread the clutch puller tool into the clutch retaining bolt hole (Figure 24-4, Page 24-5).
6. Use a 1/2-in. drive air wrench to tighten the clutch puller tool. The drive clutch (2) will pull free of the crankshaft.
7. Support the drive clutch assembly in your hand and back the clutch puller tool out of the crankshaft.

⚠ CAUTION

- Do not hit or tap the clutch with a hammer. Do not pry the clutch. These actions will damage the clutch.

DRIVE CLUTCH CLEANING AND INSPECTION

1. Use a dry, lint-free cloth to clean clutch parts.

⚠ CAUTION

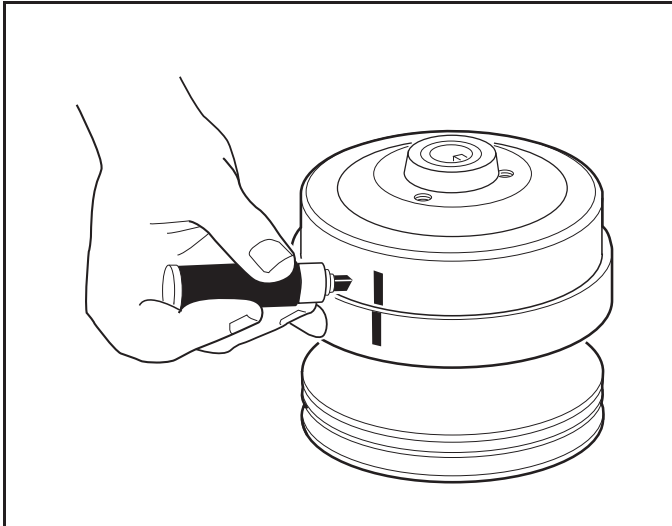
- Do not lubricate the drive clutch. Lubricants attract dirt and dust, which interfere with proper clutch operation.
 - Use only a dry cloth to lightly wipe the shaft of the fixed sheave (18) (Figure 24-2, Page 24-4). Do not use a brush or steel wool. These will damage the surface of the shaft.
 - Do not use solvents. Solvents will damage the lubricating characteristics of the bushings.
2. Inspect the belt contact surfaces of the clutch sheaves for wear. If any area of a sheave contact surface has wear of 0.060 in. (1.52 mm) or more, the clutch should be replaced.

DRIVE CLUTCH DISASSEMBLY

⚠ CAUTION

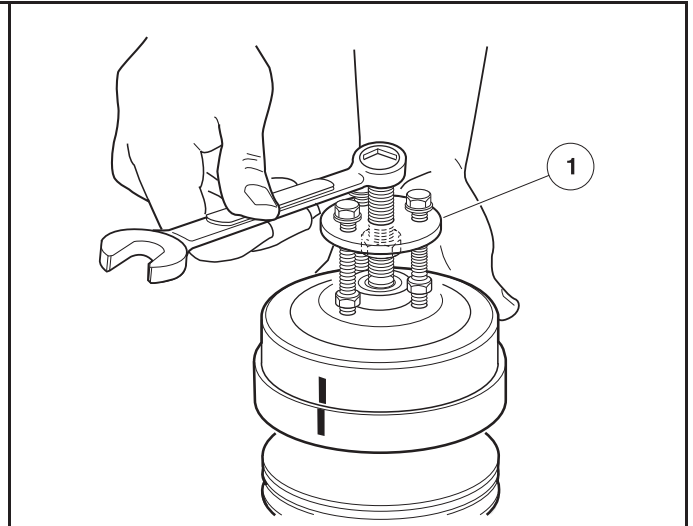
- The drive clutch is balanced as an assembly. Before disassembly, make match marks on the drive clutch hub and on the moveable sheave so they can be reassembled in the same positions (Figure 24-5, Page 24-7).
1. Make match marks on the drive clutch hub and on the moveable face (Figure 24-5, Page 24-7).

2. Remove the drive clutch hub (5) (**Figure 24-2, Page 24-4**):
 - 2.1. Remove the three plugs (4) from the clutch puller attachment holes.
 - 2.2. Thread the center bolt of the Drive Clutch Hub Puller (1) into clutch until the stop nut touches the clutch, then back the bolt out one-half turn (**Figure 24-6, Page 24-7**).
 - 2.3. Thread the three small bolts of the puller into corresponding holes in the clutch. Tighten bolts evenly, making sure the face of the puller plate is parallel to the face of the clutch (**Figure 24-6, Page 24-7**).
 - 2.4. Unscrew the puller center bolt out of the clutch to pull drive clutch hub off.



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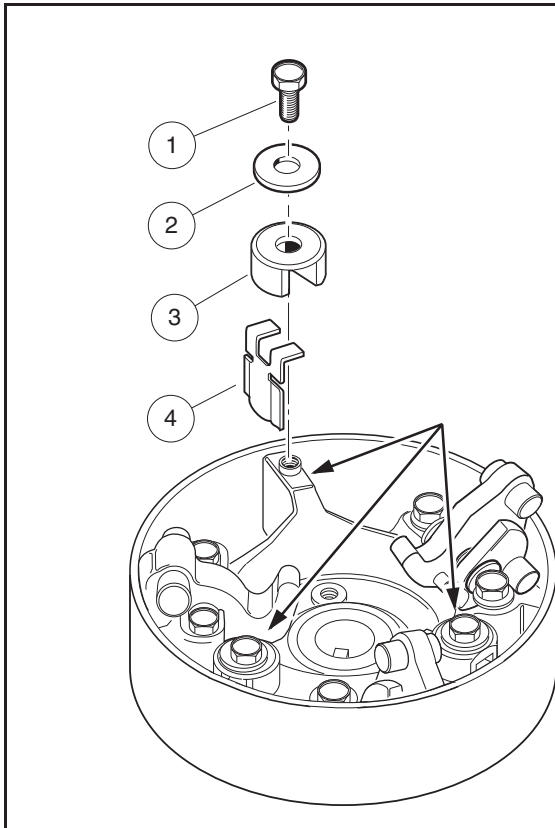
Figure 24-5 Mark Drive Clutch Hub



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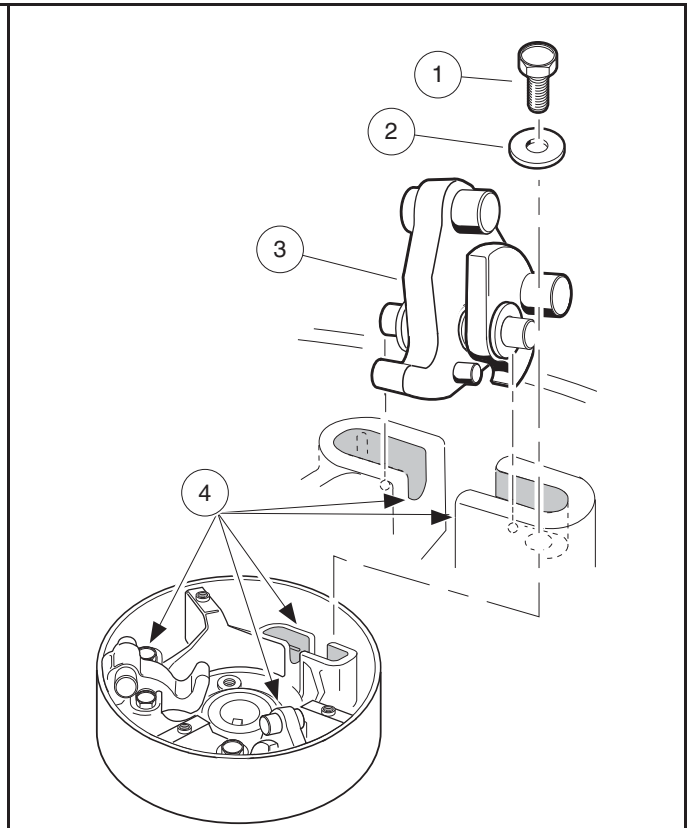
Figure 24-6 Remove Drive Clutch Hub

3. Remove the thrust washer (9) from the moveable sheave (13) (**Figure 24-2, Page 24-4**).
4. Remove the drive buttons (3) by removing the screws (1), flat washers (2), and drive button take-up springs (4) as shown (**Figure 24-7, Page 24-8**).



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Figure 24-7 Drive Button Mounting



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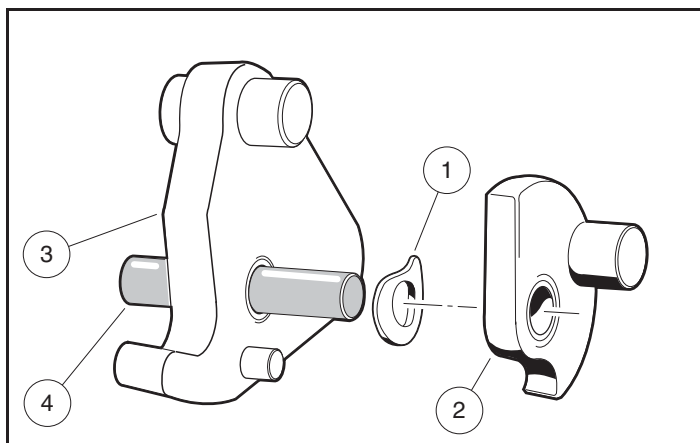
Figure 24-8 Weight Position

5. Remove the clutch weights:

- 5.1. Remove the screws (1) and flat washers (2) attaching the weights (3) as shown (Figure 24-8, Page 24-8).
- 5.2. Pull the weight assemblies (3), with pins, from slots (4) in the clutch. **See following NOTE.**

NOTE: Before removing, note the orientation of the wave washer (1) and secondary weight (2) on the primary weight (3) (Figure 24-9, Page 24-9).

- 5.3. Remove the plastic washers, weights (2 and 3) and wave washer (1) from the pin (4). Retain all parts.



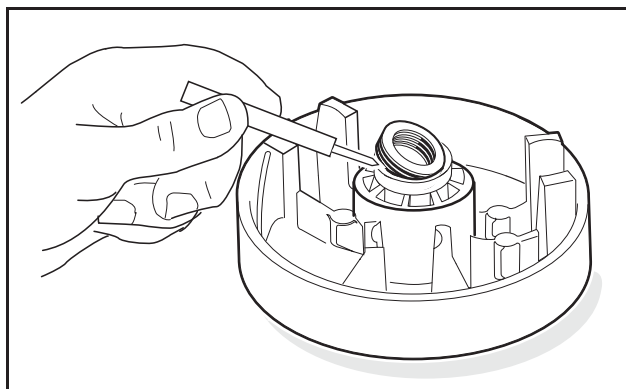
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Figure 24-9 Primary and Secondary Weights, Wave Washer and Pin

6. Remove the retaining ring (6) from the shaft of the fixed sheave (18) and slide the moveable sheave (13) off the shaft (**Figure 24-2, Page 24-4**). See following **NOTE**.

NOTE: If the moveable sheave is removed from the hub of the fixed sheave, the spiral back-up rings (11) must be replaced with new rings (**Figure 24-2, Page 24-4**).

7. Remove the spacer (14) and spring (15) (**Figure 24-2, Page 24-4**).
8. Use a scribe or small pick to remove the spiral backup rings (11) from each end of the bore in the fixed sheave (**Figure 24-2, Page 24-4**). See also **Figure 24-10, Page 24-9**. Discard the rings.



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Figure 24-10 Spiral Back-up Rings

INSPECTION OF DRIVE CLUTCH PARTS

1. Inspect the idler spacer (17) for smoothness (**Figure 24-2, Page 24-4**).
2. Inspect the bore of the moveable sheave (13) for scarring or wear. The moveable sheave must be replaced if the bore is worn to a diameter of 0.883 in. (22.4 mm) or larger (**Figure 24-2, Page 24-4**).
3. Inspect the steel shaft on the fixed sheave (18). There should be no measurable wear anywhere on the shaft. Replace the shaft if it is worn, scratched, or damaged.
4. Inspect the thrust washer (9) for wear. If it is worn more than 0.030 in. (0.76 mm), turn it over or replace it with a new one.

5. Inspect the primary weights (8) and the hub casting for wear. If the primary weights show signs they are touching the casting, the tips of the weights have worn beyond specification and they must be replaced.
6. Inspect the pins on the primary weights (8). There should be no measurable wear. Replace them if they are worn, scratched, or damaged.
7. Inspect the drive belt pulley sheaves for excessive wear or damage. If the sheaves are excessively worn or damaged, replace the entire fixed sheave.

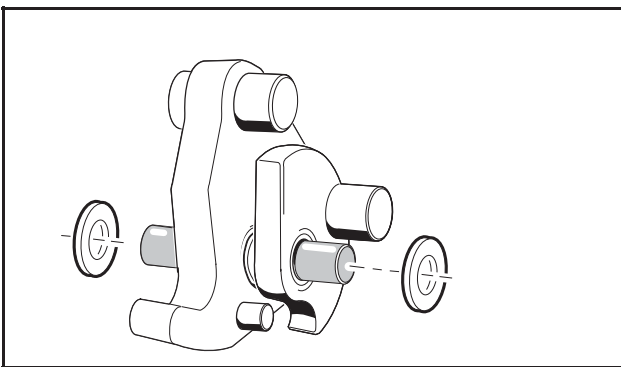
DRIVE CLUTCH ASSEMBLY

1. Install the spring (15) into the cup of the idler spacer (17).
2. Install the spacer (14) onto the shaft of the fixed sheave.
3. Install a new spiral backup ring (11) in each end of the bore of the moveable sheave (13).
4. Install the moveable sheave (13) onto the shaft of the fixed sheave (18).

⚠ CAUTION

- To avoid damaging the spiral back-up rings, be very careful when installing the moveable sheave.

- 4.1. Rotate the moveable sheave clockwise while installing it onto the shaft.
- 4.2. Install the retaining ring (6) (**Figure 24-2, Page 24-4**).
5. Install the primary weights (3) on the mounting pins (4) (**Figure 24-9, Page 24-9**).
6. Install a wave washer (1) on each mounting pin (4). Make sure that the concave side of the washer faces the side of the primary weight (3) with the small guide pin protruding from it (**Figure 24-9, Page 24-9**).
7. Install the secondary weights (2) onto the mounting pins (4) with the weight pins on the secondary weights pointing away from the primary weights (3). The wave washers should be between the primary and secondary weights (**Figure 24-9, Page 24-9**).
8. Install white plastic flat washers on each end of the mounting pin and push them against the outside surfaces of the weights. Center the weights and washers on the mounting pin (**Figure 24-11, Page 24-10**).
9. Install the weight assemblies into the slots (4) in the hub casting (**Figure 24-8, Page 24-8**). Make sure the mounting pin protrudes an equal amount on each side of the weights when the assemblies are in position (**Figure 24-11, Page 24-10**).



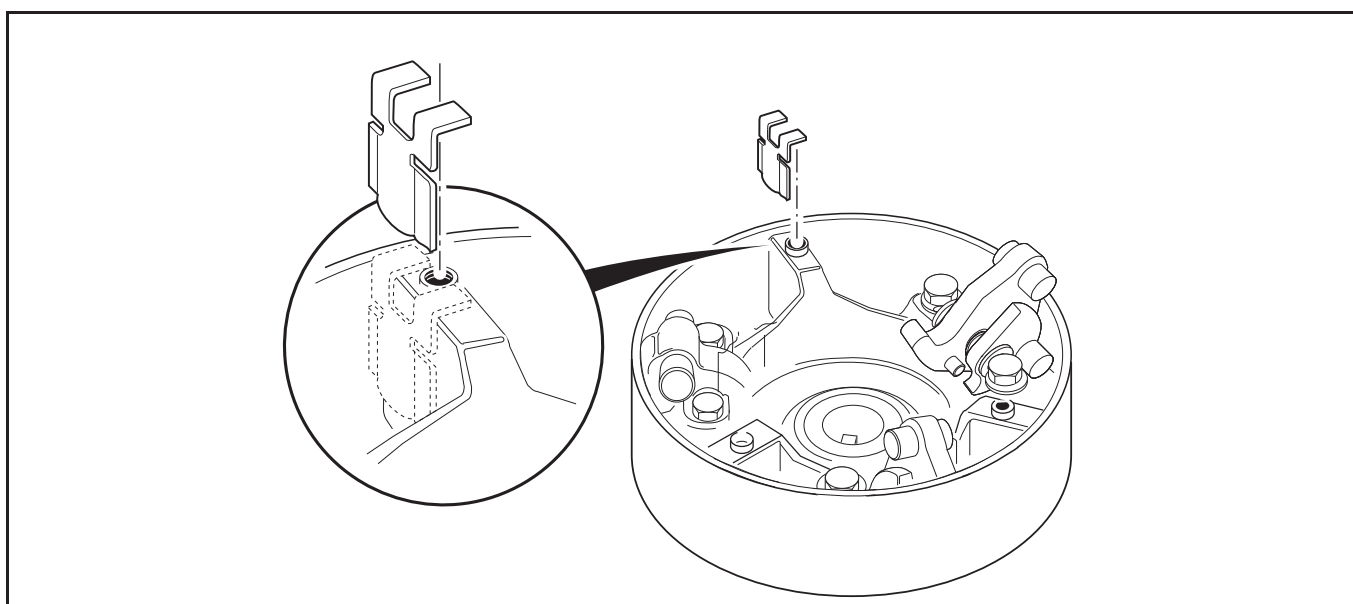
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Figure 24-11 Install White Washers

10. Install the 1/4-20 bolts (1) and washers (2) and tighten them to 10 ft·lb (13 N·m) (**Figure 24-8, Page 24-8**).
See following NOTE.

NOTE: Make sure there is at least a (minimum) gap of 0.020 in. (0.51 mm) between each end of the mounting pin and the mounting bolt.

11. Install three drive button take-up springs.
- 11.1. Install each spring on right-hand side of the three button mounting posts (when looking into the interior of the clutch drive hub, and with the rib at a twelve o'clock position) as shown (**Figure 24-12, Page 24-11**).
12. Compress each take-up spring and install the drive button over the rib and take-up spring (**Figure 24-7, Page 24-8**).
13. Install a drive button retaining bolt (1) with flat washer (2) through each button (3) and into the rib. Tighten the bolts to 34 in·lb (3.8 N·m) (**Figure 24-7, Page 24-8**).
14. Install the thrust washer (9) onto the moveable sheave (13) (**Figure 24-2, Page 24-4**).
15. Install the hub assembly (5) on the moveable sheave (13) and align the match marks made before disassembling the clutch. Press the hub assembly on by hand.
16. Replace the three plastic plugs (4) into the holes (**Figure 24-2, Page 24-4**).



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Figure 24-12 Correct Orientation of Drive Button Take-up Springs

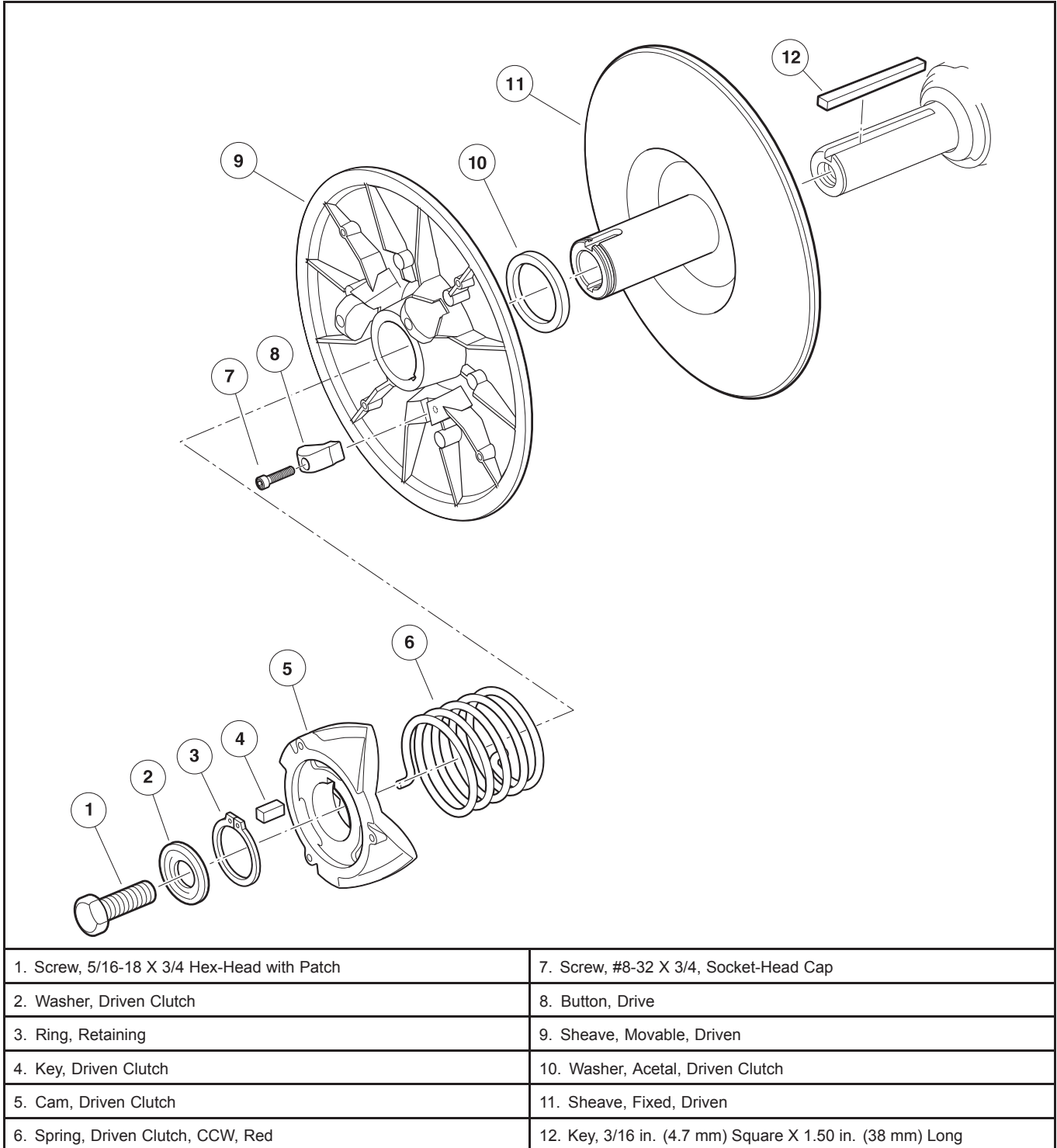
DRIVE CLUTCH INSTALLATION

1. Place the drive clutch assembly on the crankshaft taper. Position the mounting washers (2 and 3) on the bolt (1) and start the bolt into the crankshaft (**Figure 24-2, Page 24-4**). **See following NOTE.**

NOTE: The drive clutch retaining bolt has right-hand threads. The manufacturer recommends replacing the drive clutch retaining bolt when installing the drive clutch. If a new bolt is not available, clean the threads of the original bolt and apply Loctite® 242 to the threaded end prior to installation.

2. Tighten the drive clutch retaining bolt (1) to 35 ft·lb (47.5 N·m) (**Figure 24-2, Page 24-4**).
3. Install the starter/generator belt and adjust belt tension as instructed. **See Belt Tension Adjustment For EFI Engines, Section 20, Page 20-16.**
4. Install the drive belt as instructed. **See Drive Belt Installation on page 24-3.**
5. Connect battery and spark plug wire. **See Connect the Battery - Gasoline Vehicles on page 1-4.**
6. Drive the vehicle and check for proper operation.

DRIVEN CLUTCH



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Figure 24-13 Driven Clutch – Exploded View

DRIVEN CLUTCH REMOVAL

1. Remove the drive belt as instructed. **See Drive Belt Removal on page 24-3.**
2. Remove the bolt (1) and mounting washer (2) from the transaxle input shaft (**Figure 24-13, Page 24-12**). Discard the bolt.

NOTE: The bolt (1) must be replaced with a new bolt containing a locking patch that will prevent the bolt from loosening.

3. Grasp the driven clutch assembly and slide it off the shaft.
4. Leave the key (12) in the keyway (**Figure 24-13, Page 24-12**).
5. Inspect the key for damage. Replace as necessary.

DRIVEN CLUTCH DISASSEMBLY

⚠ CAUTION

- The driven clutch is balanced as an assembly. Before disassembly, make match marks on the driven clutch fixed sheave and moveable sheave so they can be reassembled in the same positions.

1. Make match marks on the driven clutch fixed sheave and on the moveable sheave to maintain balance upon reassembly.
2. Set the edge of the clutch body (1) on a clean, flat surface (**Figure 24-14, Page 24-13**).

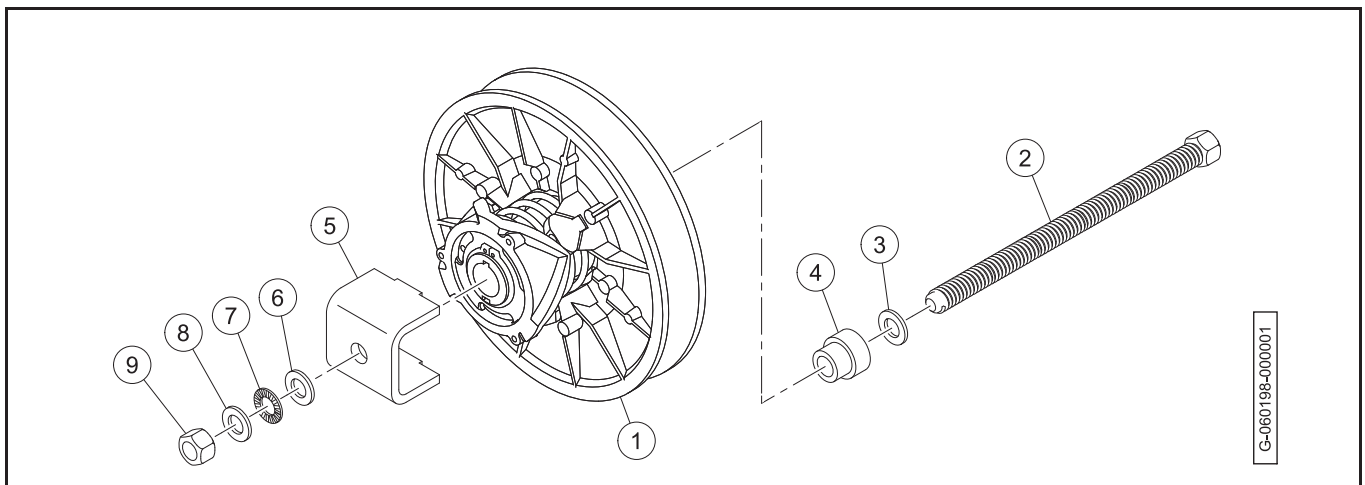


Figure 24-14 Driven Clutch Tool - Disassembly

3. Assemble the threaded bolt (2) through the washer (3) and thrust collar (4).

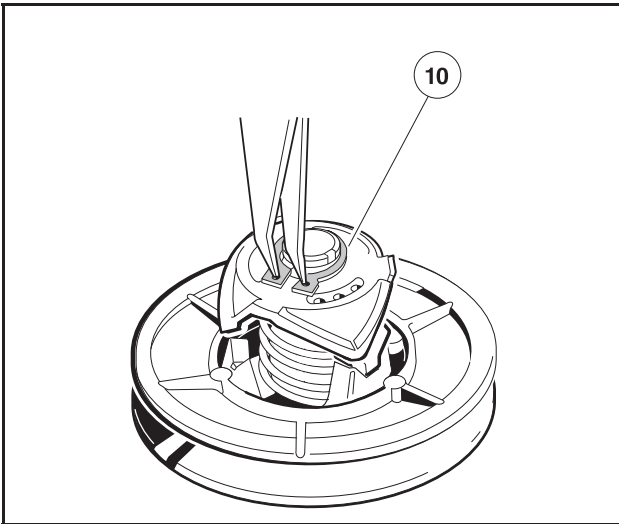
NOTE: It is very important that the bolt, washers, and thrust bearing assembly be assembled in the order described and shown.

4. Slide the threaded bolt assembly through the clutch body until the threaded bolt and thrust collar are against the fixed sheave.
5. Install the cam press plate (5), thrust washer (6), thrust bearing (7), thrust washer (8), and nut (9) onto the threaded bolt.
6. Thread the nut down onto the cam hub, centering the press hub onto the cam hub.
7. Use two wrenches and hold the threaded bolt head while tightening the cam press plate to press the cam onto the keyed shaft. Advance the cam press plate until it is firm against the shaft end.

⚠ WARNING

- Do not place fingers under the cam when removing the cam. The moveable face may spin when the cam buttons release from the cam ramps, resulting in severe personal injury.

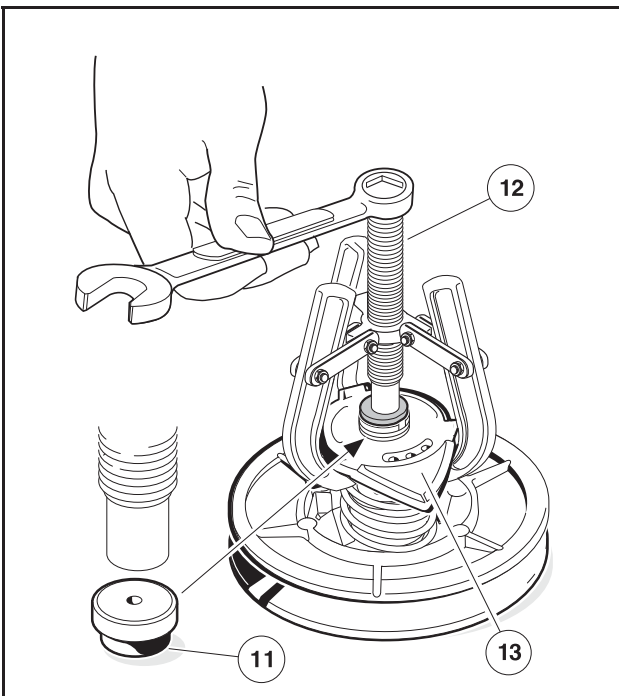
8. Remove the retaining ring (10) (Figure 24-15, Page 24-14).



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Figure 24-15 Remove Retaining Ring

9. Insert a puller plug (11) into the shaft bore (Figure 24-16, Page 24-14).

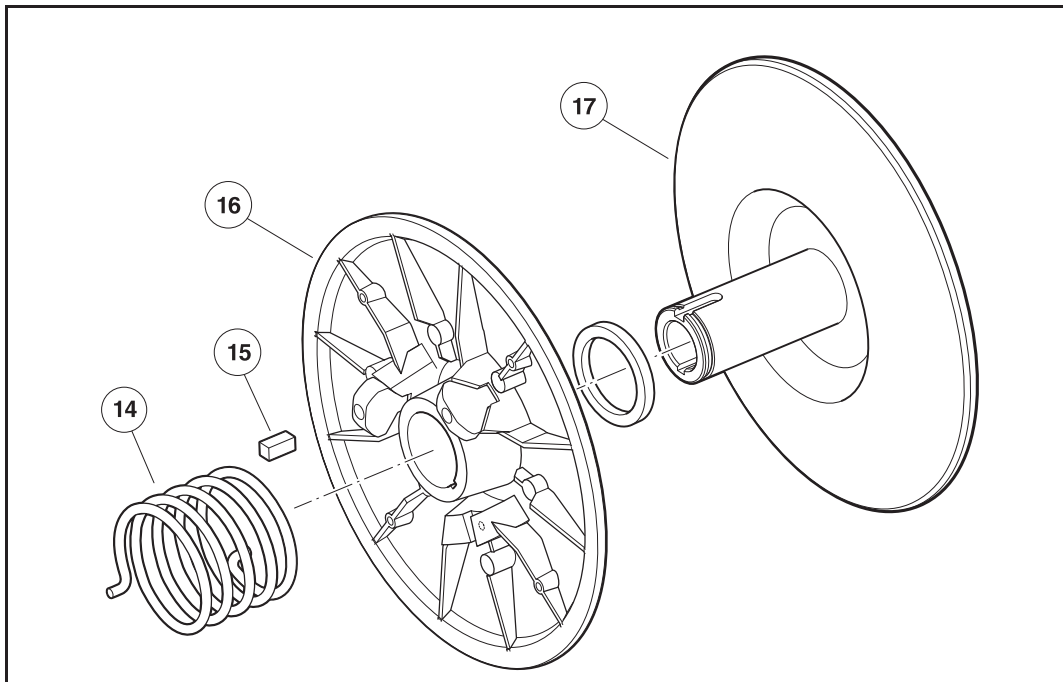


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Figure 24-16 Cam Removal

10. Use a driven clutch cam puller (12) to remove the cam (13) from the fixed sheave.

11. Remove the spring (14) (Figure 24-17, Page 24-15).



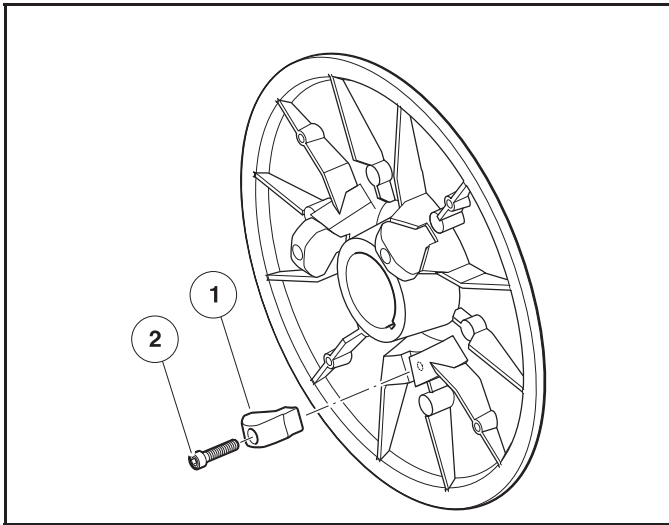
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Figure 24-17 Driven Clutch Disassembly

12. Inspect the key (15) for damage. Replace as necessary.
13. Slide the moveable sheave (16) off the fixed sheave (17).

DRIVEN CLUTCH INSPECTION

1. Inspect the cam for excessive wear. Replace it if necessary.
2. Inspect the drive buttons (2) for excessive wear (Figure 24-18, Page 24-16). Replace if necessary. To remove the drive buttons, remove the socket-head cap screws (1) and then the buttons.



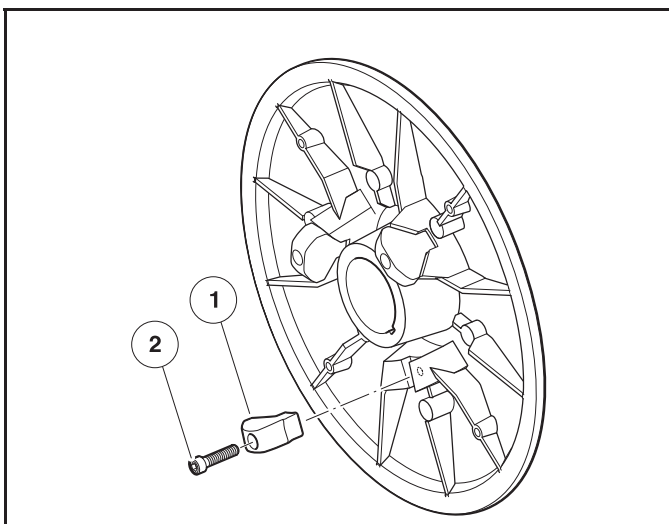
2961C

Figure 24-18 Drive Button Inspection

3. Inspect the smooth surface on the fixed and moveable sheaves. Sheaves must be replaced if surfaces are worn more than 0.060 in. (1.5 mm).
4. Inspect the bronze bearing in the moveable sheave. If the bearing bore diameter is more than 1.384 in. (35.15 mm), the entire moveable sheave must be replaced.
5. Inspect the shaft of the fixed sheave. There should be no noticeable wear. Replace the fixed sheave if it is worn, scratched or damaged.
6. Inspect the retaining ring. If the outside diameter is more than 1.607 in. (40.82 mm), replace the retaining ring.

DRIVEN CLUTCH ASSEMBLY

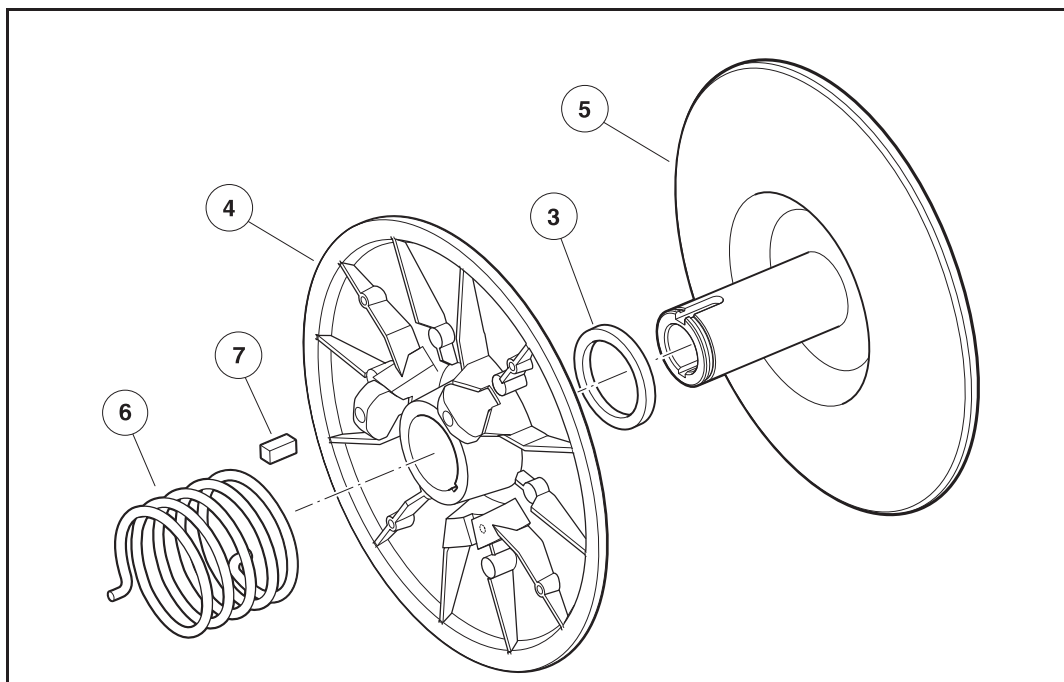
1. Place the three drive buttons (2) in position. Apply one drop of Loctite® 222 to each of the socket-head cap screws (1) and then install and tighten them to 8 in·lb (0.9 N·m) (**Figure 24-19, Page 24-16**).



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Figure 24-19 Drive Button Installation

2. Slide the acetal washer (3) and moveable sheave (4) onto the fixed sheave (5) (**Figure 24-20, Page 24-17**).



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Figure 24-20 Driven Clutch Assembly

3. Place the end of the spring (6) into the hole in the moveable sheave (9).
4. Install the key (7) into the keyway of the fixed sheave shaft.
5. Holding the cam (8) in position for assembly on the shaft, install the other end of the spring into the center spring hole of the cam. Rotate the cam until the keyway is aligned with the key on the fixed sheave, and then start the cam onto the shaft approximately 1/4 to 3/8 in. (6.3 to 9.5 mm).
6. With the clutch loosely assembled, set the edge of the clutch body (9) on a clean, flat surface (**Figure 24-21, Page 24-17**).

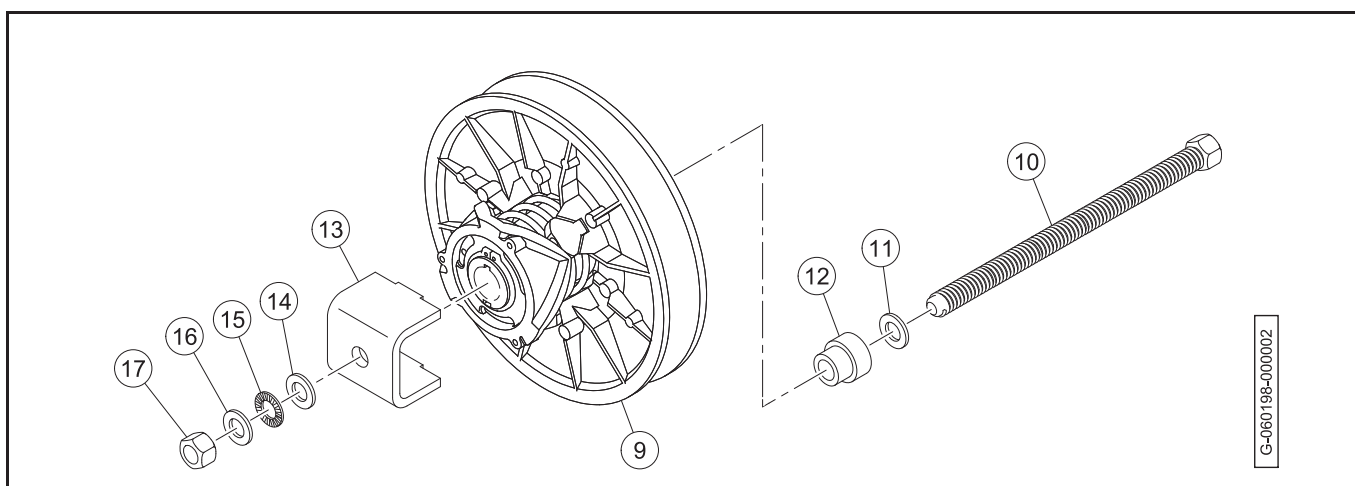


Figure 24-21 Driven Clutch Tool - Assembly

7. Assemble the threaded bolt (10) through the washer (11) and thrust collar (12).

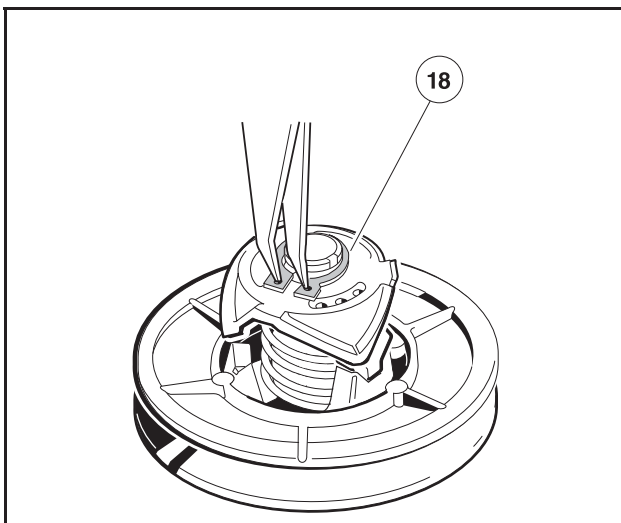
NOTE: It is very important that the bolt, washers, and thrust bearing assembly be assembled in the order described and shown.

8. Slide the threaded bolt assembly through the clutch body until the threaded bolt and thrust collar are against the fixed sheave.
9. Hold the clutch assembly and cam installation tool together and place the fixed sheave down on spaced blocks.
10. Install the cam press plate (13), thrust washer (14), thrust bearing (15), thrust washer (16), and nut (17) onto the threaded bolt.
11. Thread the nut down onto the cam hub, centering the press hub onto the cam hub.
12. Hold the fixed sheave of the clutch and rotate the moveable sheave of the clutch one-third turn counterclockwise. The match marks made before disassembly should now align.
13. Use two wrenches and hold the threaded bolt head while tightening the cam press plate to press the cam onto the keyed shaft. Advance the cam press plate until it is firm against the shaft end.

⚠ WARNING

- Do not place fingers under the cam when removing the cam. The moveable face may spin when the cam buttons release from the cam ramps, resulting in severe personal injury.

14. Install the retaining ring (18) (Figure 24-22, Page 24-18).



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Figure 24-22 Install Retaining Ring

15. Remove the driven clutch tool.

DRIVEN CLUTCH INSTALLATION

1. To install the driven clutch, reverse the removal procedure.
2. Make sure that the washer (2) is mounted with the flat portion of the washer against the driven clutch (Figure 24-13, Page 24-12).
3. Tighten the new bolt (1) to 18 ft·lb (24.4 N·m). **See following NOTE.**

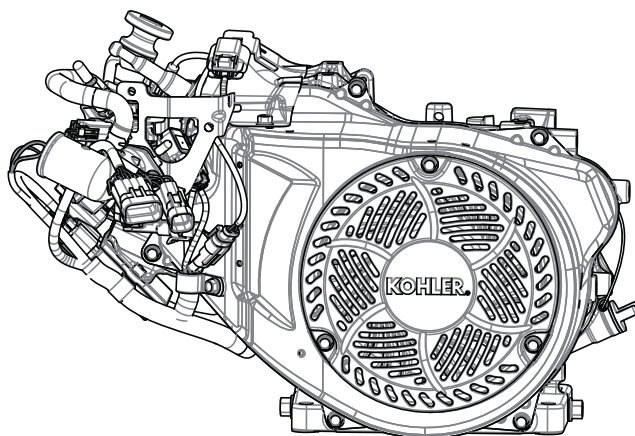
NOTE: The bolt (1) must be replaced with a new bolt containing a locking patch that will prevent the bolt from loosening.

4. Connect the battery and spark plug wire.

KOHLER® Command PRO

ECH440 for CLUB CAR

Service Manual



IMPORTANT: Read all safety precautions and instructions carefully before operating equipment. Refer to operating instruction of equipment that this engine powers.

Ensure engine is stopped and level before performing any maintenance or service.

| | |
|----|--|
| 2 | Safety |
| 3 | Maintenance |
| 5 | Specifications |
| 16 | Tools and Aids |
| 19 | Troubleshooting |
| 23 | Air Cleaner/Intake (OEM Supplied) |
| 24 | Electronic Fuel Injection (EFI) System |
| 51 | Governor System (OEM Supplied) |
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| 54 | Electrical System |
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Safety


SAFETY PRECAUTIONS


⚠ WARNING: A hazard that could result in death, serious injury, or substantial property damage.


⚠ CAUTION: A hazard that could result in minor personal injury or property damage.

NOTE: is used to notify people of important installation, operation, or maintenance information.

| | |
|--|--|
|  | <p>⚠ WARNING</p> <p>Explosive Fuel can cause fires and severe burns.</p> <p>Do not fill fuel tank while engine is hot or running.</p> |
| <p>Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.</p> | |


| | |
|---|---|
|  | <p>⚠ WARNING</p> <p>Rotating Parts can cause severe injury.</p> <p>Stay away while engine is in operation.</p> |
| <p>Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate engine with covers, shrouds, or guards removed.</p> | |


| | |
|--|---|
|  | <p>⚠ WARNING</p> <p>Carbon Monoxide can cause severe nausea, fainting or death.</p> <p>Avoid inhaling exhaust fumes.</p> |
| <p>Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled.</p> | |


| | |
|---|--|
|  | <p>⚠ WARNING</p> <p>Accidental Starts can cause severe injury or death.</p> <p>Disconnect and ground spark plug lead(s) before servicing.</p> |
| <p>Before working on engine or equipment, disable engine as follows: 1) Disconnect spark plug lead(s). 2) Disconnect negative (–) battery cable from battery.</p> | |


| | |
|---|---|
|  | <p>⚠ WARNING</p> <p>Hot Parts can cause severe burns.</p> <p>Do not touch engine while operating or just after stopping.</p> |
| <p>Never operate engine with heat shields or guards removed.</p> | |

| | |
|--|---|
|  | <p>⚠ WARNING</p> <p>Cleaning Solvents can cause severe injury or death.</p> <p>Use only in well ventilated areas away from ignition sources.</p> |
| <p>Carburetor cleaners and solvents are extremely flammable. Follow cleaner manufacturer's warnings and instructions on its proper and safe use. Never use gasoline as a cleaning agent.</p> | |


| | |
|---|--|
|  | <p>⚠ WARNING</p> <p>High Pressure Fluids can puncture skin and cause severe injury or death.</p> <p>Do not work on fuel system without proper training or safety equipment.</p> |
| <p>Fluid puncture injuries are highly toxic and hazardous. If an injury occurs, seek immediate medical attention.</p> | |

| | |
|---|--|
|  | <p>⚠ CAUTION</p> <p>Electrical Shock can cause injury.</p> <p>Do not touch wires while engine is running.</p> |
|---|--|

| | |
|--|--|
|  | <p>⚠ CAUTION</p> <p>Damaging Crankshaft and Flywheel can cause personal injury.</p> |
| <p>Using improper procedures can lead to broken fragments. Broken fragments could be thrown from engine. Always observe and use precautions and procedures when installing flywheel.</p> | |

| | |
|---|--|
|  | <p>⚠ CAUTION</p> <p>Failure to utilize or reassemble debris screen as designed could result in debris screen failure and serious personal injury.</p> |
|---|--|

MAINTENANCE INSTRUCTIONS

| | | |
|---|---|--|
|  | ⚠ WARNING | Before working on engine or equipment, disable engine as follows: 1) Disconnect spark plug lead(s). 2) Disconnect negative (–) battery cable from battery. |
| | Accidental Starts can cause severe injury or death. Disconnect and ground spark plug lead(s) before servicing. | |

Normal maintenance, replacement or repair of emission control devices and systems may be performed by any repair establishment or individual; however, warranty repairs must be performed by a Kohler authorized dealer.

MAINTENANCE SCHEDULE

After first 100 Hours³

| | |
|---------------|--------------------|
| • Change oil. | Lubrication System |
|---------------|--------------------|

Every 100 Hours¹

| | |
|---|---------------------------|
| • Check air cleaner element; replace as necessary (OEM supplied air cleaner). | Refer to equipment manual |
|---|---------------------------|

Every 100 Hours or Annually¹

| | |
|------------------------|--------------------|
| • Clean cooling areas. | Air Cleaner/Intake |
|------------------------|--------------------|

Every 200 Hours³

| | |
|---------------|--------------------|
| • Change oil. | Lubrication System |
|---------------|--------------------|

Every 300 Hours

| | |
|---|---------------------------|
| • Check fuel filters (tank outlet filter and in-line filter) clean or replace if needed (OEM supplied if equipped). | Refer to equipment manual |
|---|---------------------------|

Every 300 Hours¹

| | |
|--|---------------------------|
| • Replace unique Electronic Fuel Injection (EFI) fuel filter (OEM supplied if equipped). | Refer to equipment manual |
|--|---------------------------|

Every 300 Hours²

| | |
|---|------------|
| • Check and adjust valve clearance when engine is cold. | Reassembly |
|---|------------|

Every 500 Hours or Annually¹

| | |
|-----------------------------------|-------------------|
| • Replace spark plug and set gap. | Electrical System |
|-----------------------------------|-------------------|

¹ Perform these procedures more frequently under severe, dusty, dirty conditions.

² Have a Kohler authorized dealer perform this service.

³ If engine is frequently used for short periods of time in ambient temperatures below 4°C (40°F), reduce oil change intervals to every 25 hours. Refer to Winter Lubrication details in Lubrication System.

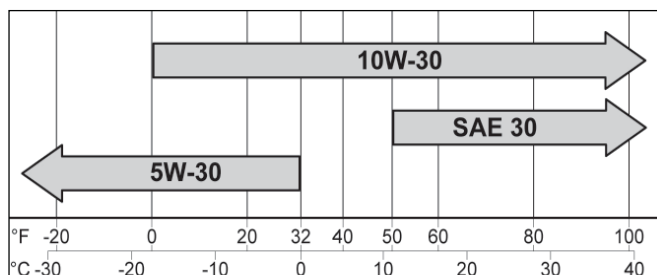
REPAIRS/SERVICE PARTS

Kohler genuine service parts can be purchased from Kohler authorized dealers. To find a local Kohler authorized dealer visit KohlerEngines.com or call 1-800-544-2444 (U.S. and Canada).


Maintenance

OIL RECOMMENDATIONS

We recommend use of Kohler oils for best performance. Other high-quality detergent oils (including synthetic) of API (American Petroleum Institute) service class SJ or higher are acceptable. Select viscosity based on air temperature at time of operation as shown in table below.



FUEL RECOMMENDATIONS

| | |
|--|---|
|  | ⚠ WARNING |
| | Explosive Fuel can cause fires and severe burns. |
| | Do not fill fuel tank while engine is hot or running. |

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.

NOTE: E15, E20 and E85 are NOT approved and should NOT be used; effects of old, stale or contaminated fuel are not warrantable.

Fuel must meet these requirements:

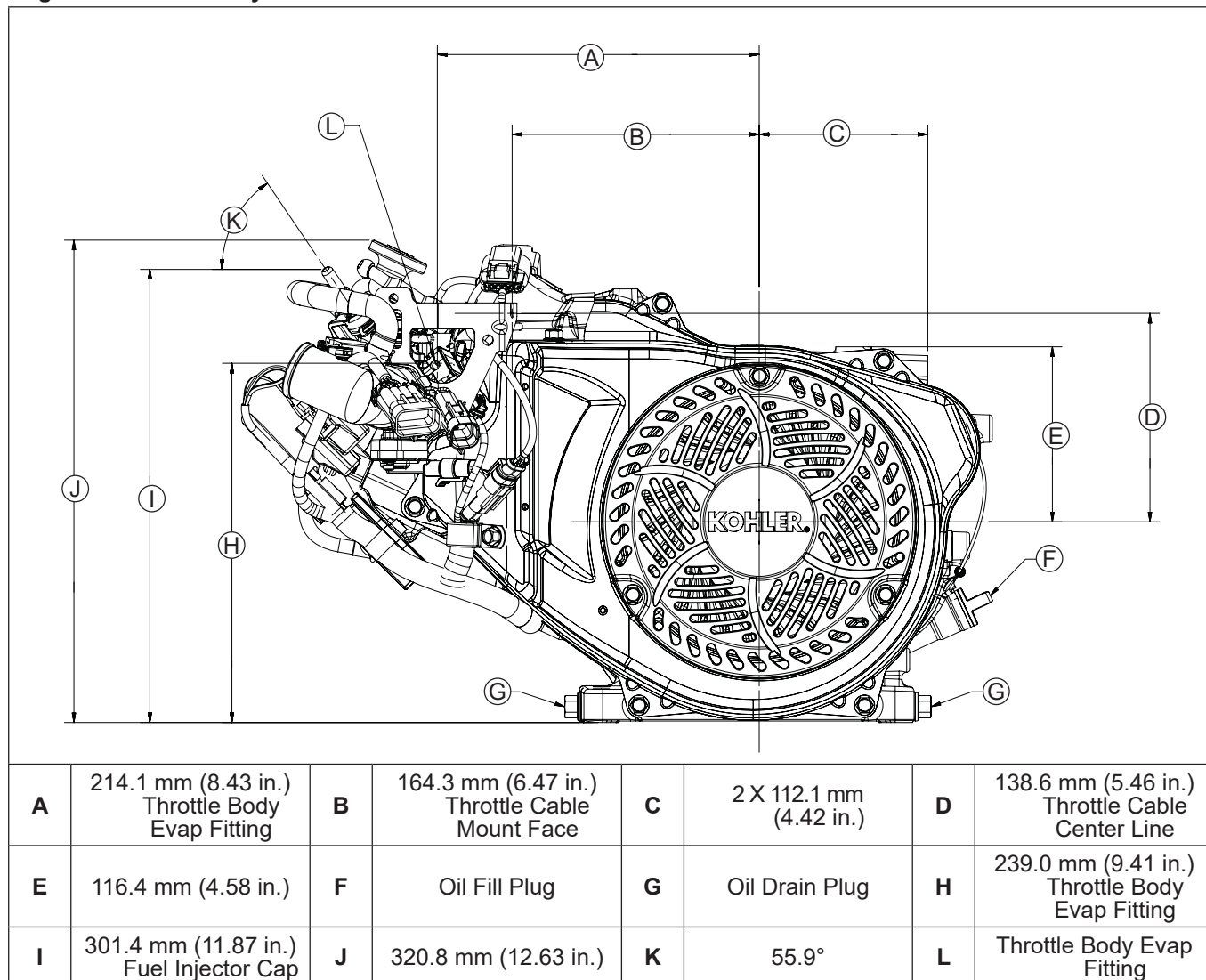
- Clean, fresh, unleaded gasoline.
- Octane rating of 87 (R+M)/2 or higher.
- Research Octane Number (RON) 90 octane minimum.
- Gasoline up to 10% ethyl alcohol, 90% unleaded is acceptable.
- Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blend (max 15% MTBE by volume) are approved.
- Do not add oil to gasoline.
- Do not overfill fuel tank.
- Do not use gasoline older than 30 days.

STORAGE

If engine will be out of service for 2 months or more follow procedure below.

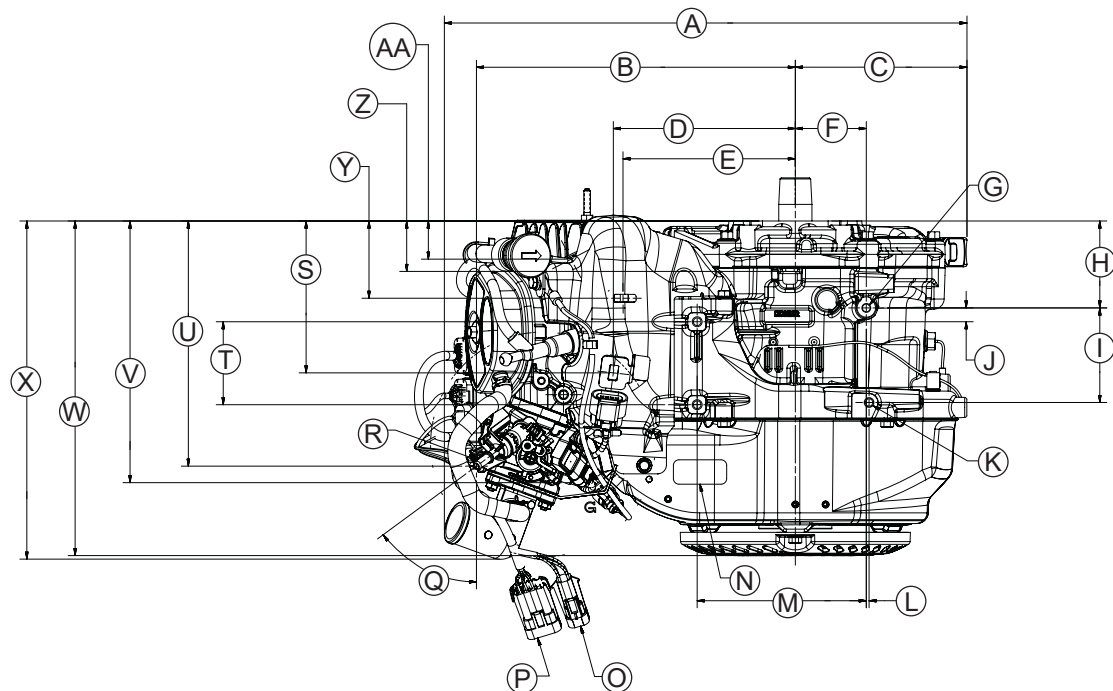
1. Add Kohler PRO Series fuel treatment or equivalent to fuel tank. Run engine 2-3 minutes to get stabilized fuel into fuel system (failures due to untreated fuel are not warrantable).
2. Change oil while engine is still warm from operation. Remove spark plug(s) and pour about 1 oz. of engine oil into cylinder(s). Replace spark plug(s) and crank engine slowly to distribute oil.
3. Disconnect negative (-) battery cable.
4. Store engine in a clean, dry place.

Engine Dimensions-Flywheel Side



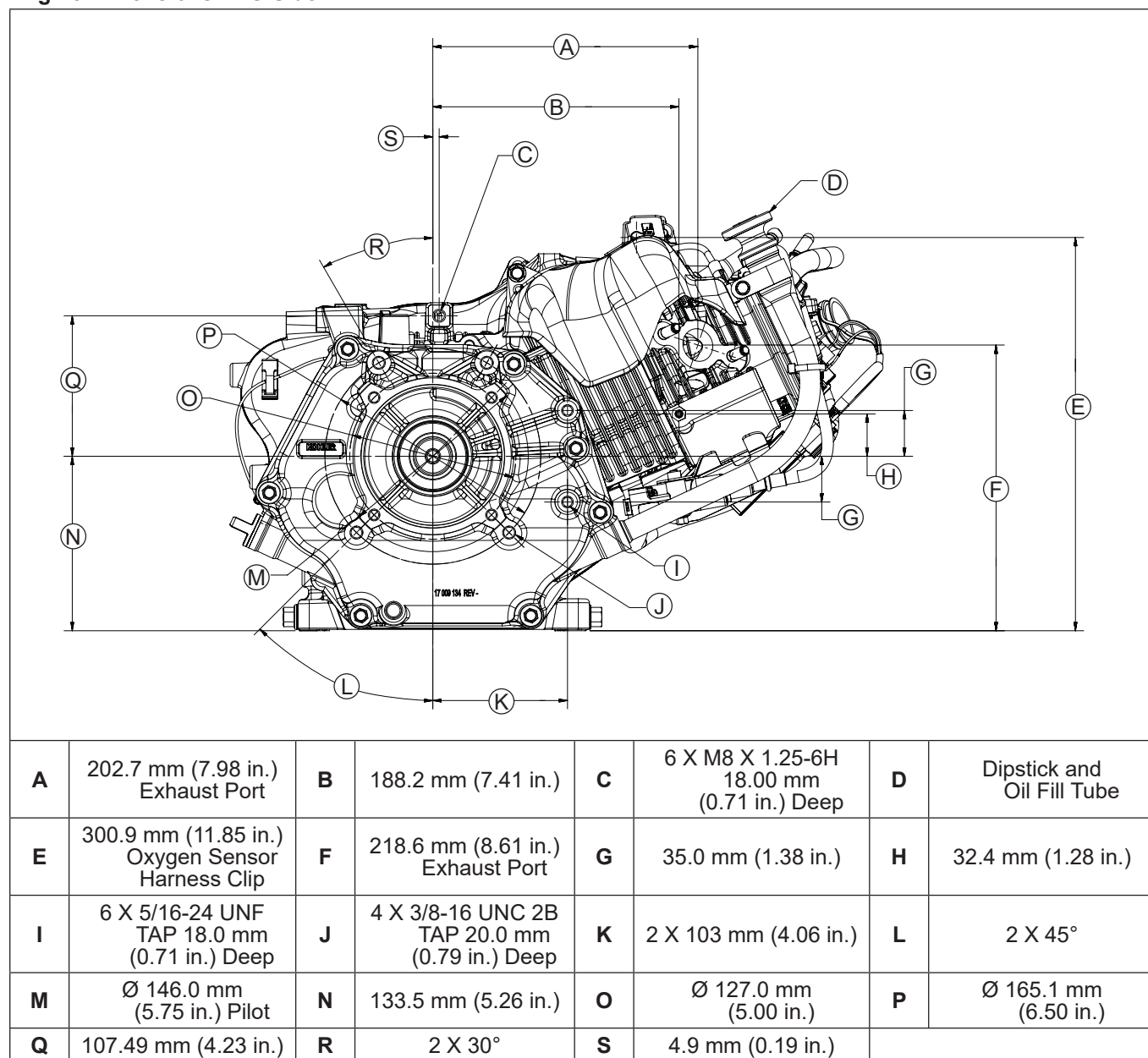
Specifications

Engine Dimensions-Top Side



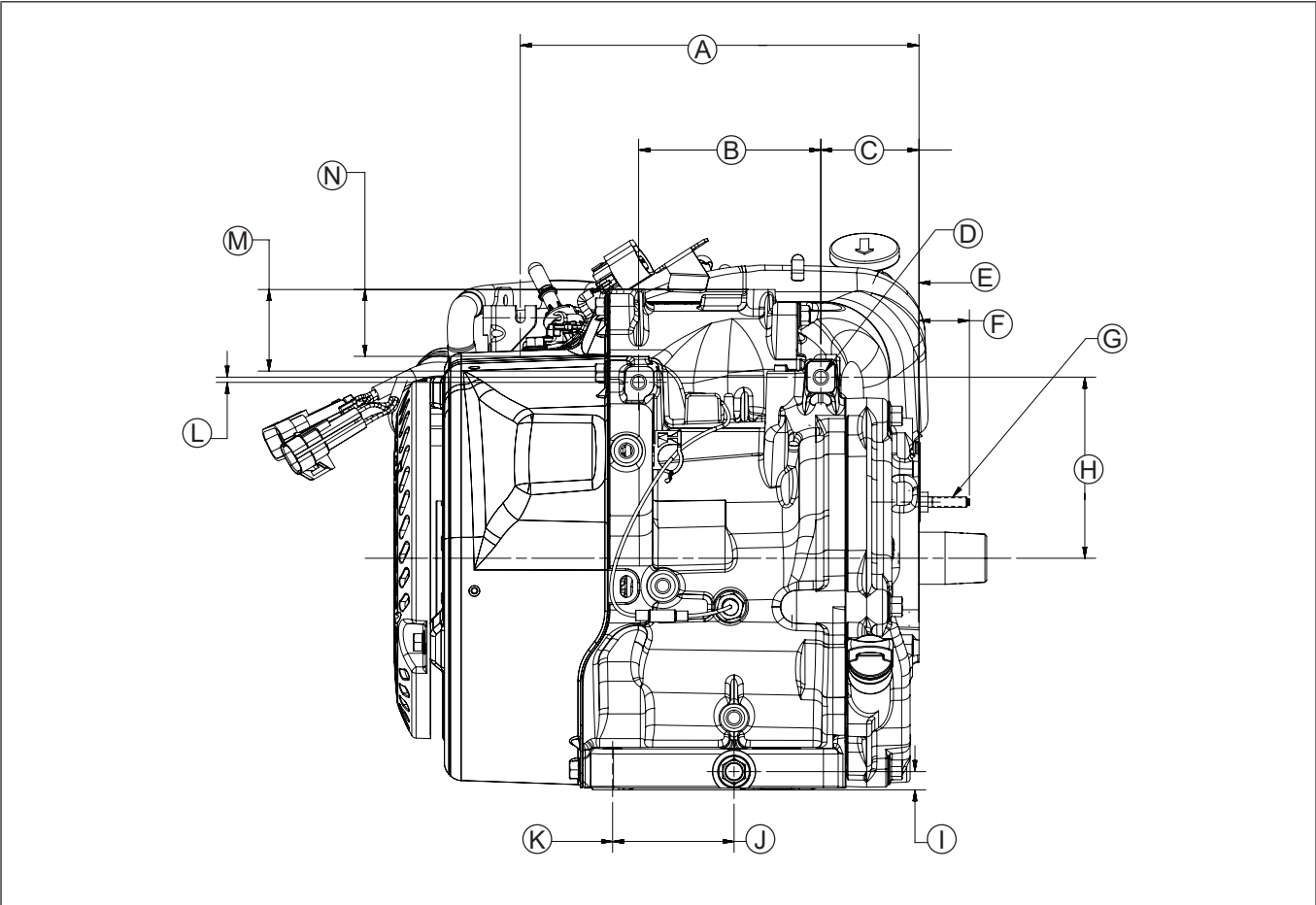
| | | | | | | | |
|----------|--|----------|--|-----------|---|----------|---|
| A | 472.4 mm (18.60 in.) | B | 288.2 mm (11.35 in.) Fuel Injector Cap | C | 155.1 mm (6.11 in.) | D | 164.5 mm (6.48 in.) Oxygen Sensor Bracket |
| E | 155.8 mm (6.13 in.) Oxygen Sensor Harness Clip | F | 64.1 mm (2.53 in.) | G | M8 X 1.25-6H Tap 19.0 mm (0.75 in.) Deep | H | 78.6 mm (3.09 in.) |
| I | 85.5 mm ± 0.36 mm (3.37 in. ± 0.01 in.) | J | 12.5 mm ± 0.43 mm (0.49 in. ± 0.02 in.) | K | 3 X M8 X 1.25-6H Tap Thru | L | 2.5 mm ± 0.36 mm (0.10 in. ± 0.01 in.) |
| M | 152.9 mm ± 0.43 mm (6.02 in. ± 0.02 in.) | N | Emission Label | O | Diagnostic Connector | P | 8-Terminal Customer Connector |
| Q | 53.7° | R | Fuel Injector Cap | S | 137.3 mm (5.41 in.) Oxygen Sensor Bracket | T | 75.0 mm ± 0.50 mm (3.0 in. ± 0.02 in.) |
| U | 221.6 mm (8.73 in.) Fuel Injector Cap | V | 236.5 mm (9.31 in.) Throttle Body Evap Fitting | W | 302.5 mm (11.91 in.) | X | 305.7 mm (12.04 in.) |
| Y | 69.8 mm (2.75 in.) Oxygen Sensor Harness Clip | Z | 45.6 mm (1.80 in.) Engine Lifting Hole Surface | AA | 34.5 mm (1.36 in.) Exhaust Port | | |

Engine Dimensions-PTO Side



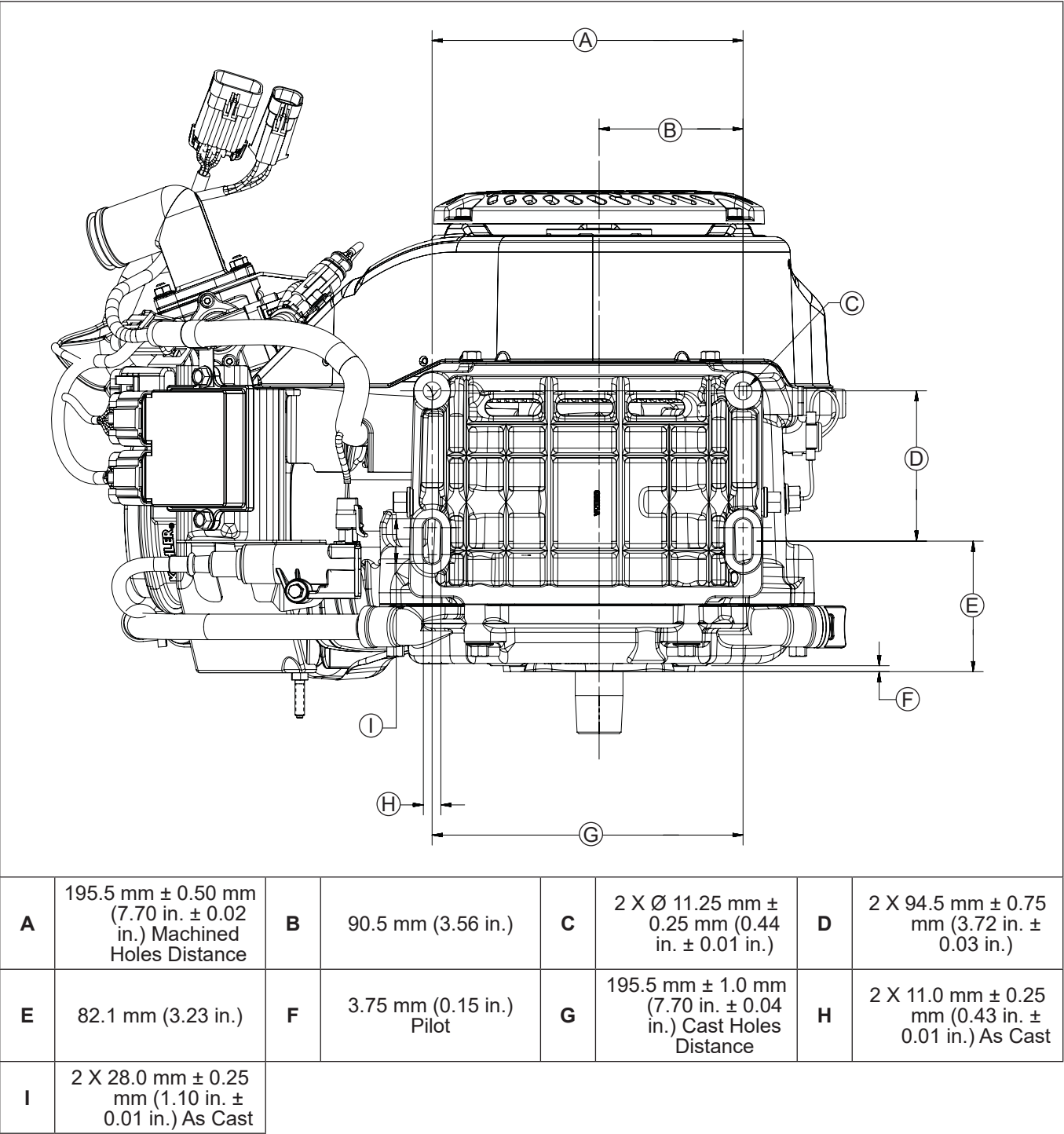
Specifications

Engine Dimensions-Opposite Cylinder Head Side



| | | | | | | | |
|----------|---|----------|------------------------|----------|--|----------|--|
| A | 229.8 mm (9.05 in.) Throttle Cable Mount Face | B | 105.0 mm (4.13 in.) | C | 56.6 mm (2.23 in.) | D | 2 X M8 X 1.25-6H Tap 22.0 mm (0.87 in.) Deep |
| E | Primary Mounting Face | F | 29.1 mm (1.14 in.) | G | M6 X 1.0-6H 14.5 mm Min. Full Thread (Ground Location) | H | 104.4 mm (4.11 in.) |
| I | 2 X 10.5 mm (0.41 in.) | J | 2 X 70.0 mm (2.76 in.) | K | Engine Mounting Hole Center Line | L | 3.0 mm (0.12 in.) |
| M | 47.0 mm (1.85 in.) | N | 38.5 mm (1.52 in.) | | | | |

Engine Dimensions-Bottom Side



Specifications

ENGINE IDENTIFICATION NUMBERS

Kohler engine identification numbers (model, specification and serial) should be referenced for efficient repair, ordering correct parts, and engine replacement.

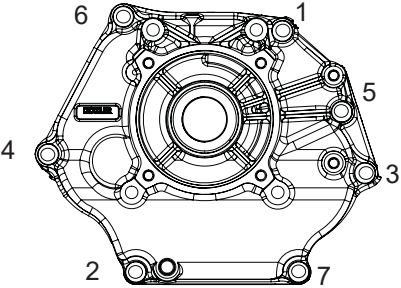
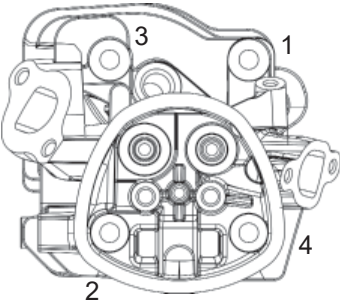
| | | |
|------------------------|-------|--------------|
| Model | | ECH440 |
| EFI Command Engine | | |
| Horizontal Shaft | | |
| Numerical Designation | | |
| Specification | | ECH440-3018 |
| Serial | | 4823500328 |
| Year Manufactured Code | | Factory Code |
| Code | Year | |
| 48 | 2018 | |
| 49 | 2019 | |
| 50 | 2020 | |

GENERAL SPECIFICATIONS^{4,5}

| | ECH440 for Club Car |
|--|-----------------------|
| Bore | 89 mm (3.5 in.) |
| Stroke | 69 mm (2.7 in.) |
| Displacement | 429 cc (26.2 cu. in.) |
| Oil Capacity (refill) | 1.1 L (1.16 U.S. qt.) |
| Maximum Angle of Operation (@ full oil level) ⁶ | 25° |

TORQUE SEQUENCES

(Refer to Torque Specifications for torque values).

| | ECH440 for Club Car |
|---------------|--|
| Closure Plate |  |
| Cylinder Head |  |

⁴ Values are in Metric units. Values in parentheses are English equivalents.
⁵ Any and all horsepower (hp) references by Kohler are Certified Power Ratings and per SAE J1940 & J1995 hp standards. Details on Certified Power Ratings can be found at KohlerEngines.com.
⁶ Exceeding maximum angle of operation may cause engine damage from insufficient lubrication.

Specifications

TORQUE SPECIFICATIONS^{4,7}

ECH440 for Club Car

Air Cleaner (OEM Supplied)

| | |
|-------------------------------|----------------------|
| Air Inlet Elbow Mounting Nuts | 8.0 N·m (71 in. lb.) |
|-------------------------------|----------------------|

Blower Housing and Sheet Metal

| | |
|--|---|
| M6 Screw | 10 N·m (89 in. lb.) |
| Cylinder Shield to Cylinder Head Ground Stud and Screw | 8.0 N·m (71 in. lb.) |
| Upper Heat Shield to Crankcase | 6.2 N·m (55 in. lb.) into new holes 4.0 N·m (35 in. lb.) into used holes |
| Blower Housing Screen Fastener | 7.3 N·m (65 in. lb.) |

Connecting Rod

| | |
|-------------------------------------|----------------------|
| Cap Fastener (torque in increments) | 20 N·m (177 in. lb.) |
|-------------------------------------|----------------------|

Crankcase

| | |
|------------------------------------|------------------------|
| Engine Temperature Sensor Fastener | 11.9 N·m (105 in. lb.) |
| Oil Fill Tube Bracket Screw | 5.4 N·m (48 in. lb.) |
| Oil Drain Plug | 18 N·m (13 ft. lb.) |
| Oil Sentry™ Level Switch Screw | 8 N·m (71 in. lb.) |
| Oil Sentry™ Wire Lead Nut | 10 N·m (89 in. lb.) |

Closure Plate Screw (torque sequence on page 10)

| | |
|----------|----------------------|
| Fastener | 24 N·m (212 in. lb.) |
|----------|----------------------|

Cylinder Head (torque sequence on page 10)

| | |
|-----------------------------------|--|
| Fastener (torque in 2 increments) | First to 25 N·m (221 in. lb.) Finally to 57.5 N·m (509 in. lb.) |
| Rocker Arm Stud | 13.6 N·m (120 in. lb.) |
| Rocker Arm Pivot Jam Nut | 10 N·m (89 in. lb.) |

Flywheel

| | |
|---------------|------------------------|
| Retaining Nut | 113 N·m (1000 in. lb.) |
|---------------|------------------------|

Ignition

| | |
|---|-----------------------|
| Electronic Control Unit (ECU) to Cylinder Shield Fastener | 8.0 N·m (71 in. lb.) |
| Spark Plug | 27 N·m (20 ft. lb.) |
| Ignition Coil Fastener | 10.2 N·m (90 in. lb.) |
| Crankshaft Position Sensor to Bracket Screw | 4.2 N·m (37 in. lb.) |
| Crankshaft Position Sensor Bracket to Crankcase Screw | 7.3 N·m (65 in. lb.) |
| Ground Wire Fastener | 7.3 N·m (65 in. lb.) |

Muffler (OEM Supplied)

| | |
|--|----------------------|
| Oxygen Sensor 14 mm (9/16 in.) wrench size | 18 N·m (159 in. lb.) |
|--|----------------------|

⁴ Values are in Metric units. Values in parentheses are English equivalents.

⁷ Lubricate threads with engine oil prior to assembly.

Specifications

TORQUE SPECIFICATIONS^{4,7}

ECH440 for Club Car

| | |
|---|------------------------|
| Throttle Body | |
| Studs | 10 N·m (89 in. lb.) |
| Primary Mounting Nuts | 8.0 N·m (71 in. lb.) |
| Temperature/Manifold Absolute Pressure (TMAP) Sensor Fastener | 7.3 N·m (65 in. lb.) |
| Throttle Position Sensor (TPS) Fastener | 1.3 N·m (11.5 in. lb.) |
| Throttle Lever Fastener | 1.3 N·m (11.5 in. lb.) |
| Fuel Injector Cap Fastener | 7.3 N·m (65 in. lb.) |

Valve Cover

| | |
|----------|---------------------|
| Fastener | 10 N·m (89 in. lb.) |
|----------|---------------------|

CLEARANCE SPECIFICATIONS⁴

ECH440 for Club Car

Camshaft

| | |
|--|--------------------------------------|
| Running Clearance | 0.016/0.052 mm (0.0006/0.0020 in.) |
| Bore I.D. New | 16.000/16.018 mm (0.6299/0.6306 in.) |
| Max. Wear Limit | 16.068 mm (0.6326 in.) |
| Camshaft Bearing Surface O.D. New | 15.975 mm (0.6289 in.) |
| Max. Wear Limit | 15.90 mm (0.626 in.) |
| Cam Lobe Profile (minimum dimension, measured from base circle to top of lobe) Intake - New | 32.286 mm (1.271 in.) |
| Max. Wear Limit | 32.032 mm (1.261 in.) |
| Exhaust - New | 32.506 mm (1.280 in.) |
| Max. Wear Limit | 32.252 mm (1.270 in.) |

Connecting Rod

| | |
|--|--------------------------------------|
| Crankpin End I.D. @ 21°C (70°F) New | 37.020/37.030 mm (1.4575/1.4579 in.) |
| Max. Wear Limit | 37.08 mm (1.460 in.) |
| Connecting Rod-to-Crankpin Side Clearance New | 0.56 mm (0.022 in.) |
| Max. Wear Limit | 1.06 mm (0.042 in.) |
| Connecting Rod-to-Piston Pin Running Clearance | 0.008/0.025 mm (0.0003/0.0010 in.) |
| Piston Pin End I.D. @ 21°C (70°F) New | 20.006/20.017 mm (0.7876/0.7881 in.) |
| Max. Wear Limit | 20.03 mm (0.789 in.) |

⁴ Values are in Metric units. Values in parentheses are English equivalents.

⁷ Lubricate threads with engine oil prior to assembly.

Specifications

CLEARANCE SPECIFICATIONS⁴

ECH440 for Club Car

Crankshaft

| | |
|---|--|
| End Play (free) | 0.0508/0.254 mm (0.002/0.010 in.) |
| Ball Bearing Internal Clearance | 0.006/0.020 mm (0.0002/0.0008 in.) |
| Crankshaft O.D. (new) | 34.975/34.989 mm (1.3770/1.3775 in.) 35.009/35.027 mm (1.3783/1.3790 in.) |
| PTO end | |
| Flywheel end | |
| Connecting Rod Journal O.D. | 36.975/36.985 mm (1.4557/1.4561 in.) |
| New | |
| Max. Wear Limit | 36.92 mm (1.4535 in.) |
| Max. Taper | 2.5 microns (0.0001 in.) |
| Max. Out-of-Round | 12.7 microns (0.0005 in.) |
| Width | 28.30/28.36 mm (1.1142/1.1165 in.) |
| Runout (either end) | 0.025 mm (0.001 in.) |
| Main Bearing I.D. (Crankcase/Closure Plate) | 34.988/35.000 mm (1.3775/1.3779 in.) |
| New (installed) | |

Cylinder Bore

| | |
|-------------------|--------------------------------------|
| Bore I.D. | 89.000/89.015 mm (3.5039/3.5045 in.) |
| New | |
| Max. Wear Limit | 89.185 mm (3.5112 in.) |
| Max. Out-of-Round | 12.7 microns (0.0005 in.) |
| Max. Taper | 12.7 microns (0.0005 in.) |

Cylinder Head

| | |
|----------------------|---------------------|
| Max. Out-of-Flatness | 0.1 mm (0.0039 in.) |
|----------------------|---------------------|

Ignition

| | |
|----------------|---------------------|
| Spark Plug Gap | 1.11 mm (0.044 in.) |
|----------------|---------------------|

⁴ Values are in Metric units. Values in parentheses are English equivalents.

Specifications

CLEARANCE SPECIFICATIONS⁴

ECH440 for Club Car

Piston, Piston Rings, and Piston Pin

| | |
|--|---|
| Piston-to-Piston Pin Running Clearance | 0.002/0.016 mm (0.0001/0.0006 in.) |
| Piston Pin Bore I.D. New | 20.000/20.008 mm (0.7874/0.7877 in.) |
| Max. Wear Limit | 20.05 mm (0.7894 in.) |
| Piston Pin O.D. New | 19.992/19.998 mm (0.7871/0.7873 in.) |
| Max. Wear Limit | 19.95 mm (0.7854 in.) |
| Top and Center Compression Ring Side Clearance New Bore | 0.045 mm (0.0018 in.) |
| Used Bore (Max.) | 0.10 mm (0.004 in.) |
| Top Compression Ring End Gap New Bore | 0.250/0.400 mm (0.010/0.016 in.) |
| Used Bore (Max.) | 1.00 mm (0.039 in.) |
| Center Compression Ring End Gap New Bore | 0.640/0.800 mm (0.025/0.032 in.) |
| Used Bore (Max.) | 1.50 mm (0.059 in.) |
| Oil Control Ring-to-Groove Side Clearance | 0.09/0.15 mm (0.0035/0.0059 in.) |
| Piston Thrust Face O.D. New | 88.955/88.975 mm (3.502/3.503 in.) ⁸ |
| Max. Wear Limit | 88.82 mm (3.497 in.) |
| Piston Thrust Face-to-Cylinder Bore Running Clearance | 0.025/0.060 mm (0.001/0.002 in.) ⁸ |






Valves and Valve Lifters

| | |
|---|------------------------------------|
| Valve Lash | 0.0762/0.127 mm (0.003/0.005 in.) |
| Intake Valve Stem-to-Valve Guide Running Clearance | 0.025/0.055 mm (0.0010/0.0022 in.) |
| Exhaust Valve Stem-to-Valve Guide Running Clearance | 0.040/0.07 mm (0.0016/0.0028 in.) |
| Intake Valve Stem O.D. New | 6.57 mm (0.259 in.) |
| Max. Wear Limit | 6.40 mm (0.252 in.) |
| Exhaust Valve Stem O.D. New | 6.55 mm (0.258 in.) |
| Max. Wear Limit | 6.41 mm (0.252 in.) |
| Intake Valve Stem to Guide New | 0.025/0.055 mm (0.0010/0.0022 in.) |
| Max. Wear Limit | 0.14 mm (0.0055 in.) |
| Exhaust Valve Stem to Guide New | 0.040/0.070 mm (0.0016/0.0028 in.) |
| Max. Wear Limit | 0.11 mm (0.0043 in.) |
| Valve Guide Reamer Size Standard Intake | 6.608 mm (0.2602 in.) |
| Standard Exhaust | 6.608 mm (0.2602 in.) |
| Valve Seat Width | 1.20 mm (0.0472 in.) |
| Nominal Valve Face Angle | 45° |






⁴ Values are in Metric units. Values in parentheses are English equivalents.

⁸ Measure 29.8-30.2 mm (1.1732-1.1890 in.) above bottom of piston skirt at right angles to piston pin.

GENERAL TORQUE VALUES

| English Fastener Torque Recommendations for Standard Applications | | | | |
|---|---|---|---|---|
| Bolts, Screws, Nuts and Fasteners Assembled Into Cast Iron or Steel | | | | Grade 2 or 5 Fasteners Into Aluminum |
| Size |  Grade 2 |  Grade 5 |  Grade 8 |   |
| Tightening Torque: N·m (in. lb.) ± 20% | | | | |
| 8-32 | 2.3 (20) | 2.8 (25) | — | 2.3 (20) |
| 10-24 | 3.6 (32) | 4.5 (40) | — | 3.6 (32) |
| 10-32 | 3.6 (32) | 4.5 (40) | — | — |
| 1/4-20 | 7.9 (70) | 13.0 (115) | 18.7 (165) | 7.9 (70) |
| 1/4-28 | 9.6 (85) | 15.8 (140) | 22.6 (200) | — |
| 5/16-18 | 17.0 (150) | 28.3 (250) | 39.6 (350) | 17.0 (150) |
| 5/16-24 | 18.7 (165) | 30.5 (270) | — | — |
| 3/8-16 | 29.4 (260) | — | — | — |
| 3/8-24 | 33.9 (300) | — | — | — |

| | | | | |
|---|-------------|-------------|-------------|---|
| Tightening Torque: N·m (ft. lb.) ± 20% | | | | |
| 5/16-24 | — | — | 40.7 (30) | — |
| 3/8-16 | — | 47.5 (35) | 67.8 (50) | — |
| 3/8-24 | — | 54.2 (40) | 81.4 (60) | — |
| 7/16-14 | 47.5 (35) | 74.6 (55) | 108.5 (80) | — |
| 7/16-20 | 61.0 (45) | 101.7 (75) | 142.5 (105) | — |
| 1/2-13 | 67.8 (50) | 108.5 (80) | 155.9 (115) | — |
| 1/2-20 | 94.9 (70) | 142.4 (105) | 223.7 (165) | — |
| 9/16-12 | 101.7 (75) | 169.5 (125) | 237.3 (175) | — |
| 9/16-18 | 135.6 (100) | 223.7 (165) | 311.9 (230) | — |
| 5/8-11 | 149.5 (110) | 244.1 (180) | 352.6 (260) | — |
| 5/8-18 | 189.8 (140) | 311.9 (230) | 447.5 (330) | — |
| 3/4-10 | 199.3 (147) | 332.2 (245) | 474.6 (350) | — |
| 3/4-16 | 271.2 (200) | 440.7 (325) | 637.3 (470) | — |

| Metric Fastener Torque Recommendations for Standard Applications | | | | | | |
|--|---|---|---|--|--|-------------------------------------|
| Size | Property Class | | | | | Noncritical Fasteners Into Aluminum |
| |  4.8 |  5.8 |  8.8 |  10.9 |  12.9 | |
| Tightening Torque: N·m (in. lb.) ± 10% | | | | | | |
| M4 | 1.2 (11) | 1.7 (15) | 2.9 (26) | 4.1 (36) | 5.0 (44) | 2.0 (18) |
| M5 | 2.5 (22) | 3.2 (28) | 5.8 (51) | 8.1 (72) | 9.7 (86) | 4.0 (35) |
| M6 | 4.3 (38) | 5.7 (50) | 9.9 (88) | 14.0 (124) | 16.5 (146) | 6.8 (60) |
| M8 | 10.5 (93) | 13.6 (120) | 24.4 (216) | 33.9 (300) | 40.7 (360) | 17.0 (150) |
| Tightening Torque: N·m (ft. lb.) ± 10% | | | | | | |
| M10 | 21.7 (16) | 27.1 (20) | 47.5 (35) | 66.4 (49) | 81.4 (60) | 33.9 (25) |
| M12 | 36.6 (27) | 47.5 (35) | 82.7 (61) | 116.6 (86) | 139.7 (103) | 61.0 (45) |
| M14 | 58.3 (43) | 76.4 (56) | 131.5 (97) | 184.4 (136) | 219.7 (162) | 94.9 (70) |

| Torque Conversions | |
|-----------------------|-----------------------|
| N·m = in. lb. x 0.113 | in. lb. = N·m x 8.85 |
| N·m = ft. lb. x 1.356 | ft. lb. = N·m x 0.737 |

Tools and Aids

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

Here is a list of tools and their source.

NOTE: Not all tools listed are required to service this engine.

SEPARATE TOOL SUPPLIERS

Kohler Tools
Contact your local Kohler source of supply.

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

Design Technology Inc.
768 Burr Oak Drive
Westmont, IL 60559
Phone 630-920-1300
Fax 630-920-0011

TOOLS

| Description | Source/Part No. |
|---|--|
| Alcohol Content Tester For testing alcohol content (%) in reformulated/oxygenated fuels. | Kohler 25 455 11-S |
| Camshaft Endplay Plate For checking camshaft endplay. | SE Tools KLR-82405 |
| Camshaft Seal Protector (Aegis) For protecting seal during camshaft installation. | SE Tools KLR-82417 |
| Cylinder Leakdown Tester For checking combustion retention and if cylinder, piston, rings, or valves are worn. Individual component available: Adapter 12 mm x 14 mm (Required for leakdown test on XT-6 engines) | Kohler 25 761 05-S Design Technology Inc. DTI-731-03 |
| Dealer Tool Kit (Domestic) Complete kit of Kohler required tools. Components of 25 761 39-S Ignition System Tester Cylinder Leakdown Tester Oil Pressure Test Kit Rectifier-Regulator Tester (120 V AC/60Hz) | Kohler 25 761 39-S Kohler 25 455 01-S Kohler 25 761 05-S Kohler 25 761 06-S Kohler 25 761 20-S |
| Dealer Tool Kit (International) Complete kit of Kohler required tools. Components of 25 761 42-S Ignition System Tester Cylinder Leakdown Tester Oil Pressure Test Kit Rectifier-Regulator Tester (240 V AC/50Hz) | Kohler 25 761 42-S Kohler 25 455 01-S Kohler 25 761 05-S Kohler 25 761 06-S Kohler 25 761 41-S |
| Digital Vacuum/Pressure Tester For checking crankcase vacuum. Individual component available: Rubber Adapter Plug | Design Technology Inc. DTI-721-01 Design Technology Inc. DTI-721-10 |
| Electronic Fuel Injection (EFI) Diagnostic Software For Laptop or Desktop PC. | Kohler 25 761 23-S |
| EFI Service Kit For troubleshooting and setting up an EFI engine. Components of 24 761 01-S Fuel Pressure Tester Noid Light 90° Adapter Code Plug, Red Wire Code Plug, Blue Wire Shrader Valve Adapter Hose Wire Probe Set (2 pieces regular wire with clip; 1 piece fused wire) Hose Removal Tool, Dual Size/End (also sold as individual Kohler tool) K-Line Adapter Jumper Lead Wiring Harness | Kohler 24 761 01-S Design Technology Inc. DTI-019 DTI-021 DTI-023 DTI-027 DTI-029 DTI-037 DTI-031 DTI-033 Kohler 25 176 23-S |
| Kohler Wireless Diagnostic System Module (Bluetooth®) For wireless Android EFI diagnostics. Individual component available: Wireless Diagnostic System Interface Cable | Kohler 25 761 45-S Kohler 25 761 44-S |

Tools and Aids

TOOLS

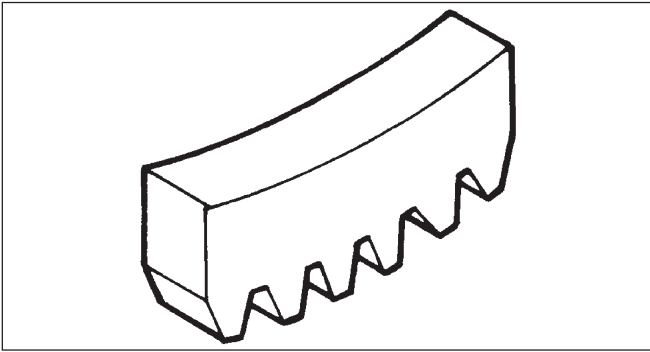
| Description | Source/Part No. |
|--|--|
| Flywheel Puller For properly removing flywheel from engine. | SE Tools KLR-82408 |
| Hose Removal Tool, Dual Size/End (also available in EFI Service Kit) Used to properly remove fuel hose from engine components. | Kohler 25 455 20-S |
| Hydraulic Valve Lifter Tool For removing and installing hydraulic lifters. | Kohler 25 761 38-S |
| Ignition System Tester For testing output on all systems, including CD. | Kohler 25 455 01-S |
| Inductive Tachometer (Digital) For checking operating speed (RPM) of an engine. | Design Technology Inc. DTI-110 |
| Offset Wrench (K and M Series) For removing and reinstalling cylinder barrel retaining nuts. | Kohler 52 455 04-S |
| Oil Pressure Test Kit For testing/verifying oil pressure on pressure lubricated engines. | Kohler 25 761 06-S |
| Rectifier-Regulator Tester (120 volt current) Rectifier-Regulator Tester (240 volt current) For testing rectifier-regulators. Components of 25 761 20-S and 25 761 41-S CS-PRO Regulator Test Harness Special Regulator Test Harness with Diode | Kohler 25 761 20-S Kohler 25 761 41-S Design Technology Inc. DTI-031R DTI-033R |
| Spark Advance Module (SAM) Tester For testing SAM (ASAM and DSAM) on engines with SMART-SPARK™. | Kohler 25 761 40-S |
| Starter Servicing Kit (All Starters) For removing and reinstalling drive retaining rings and brushes. Individual component available: Starter Brush Holding Tool (Solenoid Shift) | SE Tools KLR-82411 SE Tools KLR-82416 |
| Stepper Motor Controller Tool For testing operation of stepper motor/Digital Linear Actuator (DLA). | Kohler 25 455 21-S |
| Jumper Lead Tool For use with Stepper Motor Controller Tool to test rotary stepper motor. | Kohler 25 518 43-S |
| Triad/OHC Timing Tool Set For holding cam gears and crankshaft in timed position while installing timing belt. | Kohler 28 761 01-S |
| Valve Guide Reamer (K and M Series) For properly sizing valve guides after installation. | Design Technology Inc. DTI-K828 |
| Valve Guide Reamer O.S. (Command Series) For reaming worn valve guides to accept replacement oversize valves. Can be used in low-speed drill press or with handle below for hand reaming. | Kohler 25 455 12-S |
| Reamer Handle For hand reaming using Kohler 25 455 12-S reamer. | Design Technology Inc. DTI-K830 |

AIDS

| Description | Source/Part No. |
|---|---|
| Camshaft Lubricant (Valspar ZZ613) | Kohler 25 357 14-S |
| Dielectric Grease (GE/Novaguard G661) | Kohler 25 357 11-S |
| Dielectric Grease | Loctite® 51360 |
| Kohler Electric Starter Drive Lubricant (Inertia Drive) | Kohler 52 357 01-S |
| Kohler Electric Starter Drive Lubricant (Solenoid Shift) | Kohler 52 357 02-S |
| RTV Silicone Sealant Loctite® 5900® Heavy Body in 4 oz. aerosol dispenser. Only oxime-based, oil resistant RTV sealants, such as those listed, are approved for use. Permatex® the Right Stuff® 1 Minute Gasket™ or Loctite® Nos. 5900® or 5910® are recommended for best sealing characteristics. | Kohler 25 597 07-S Loctite® 5910® Loctite® Ultra Black 598™ Loctite® Ultra Blue 587™ Loctite® Ultra Copper 5920™ Permatex® the Right Stuff® 1 Minute Gasket™ |
| Spline Drive Lubricant | Kohler 25 357 12-S |

Tools and Aids

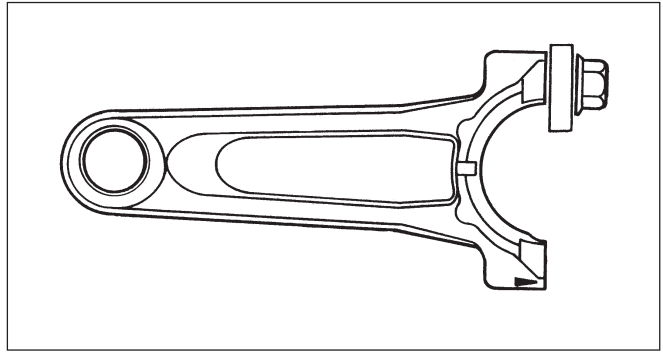
FLYWHEEL HOLDING TOOL



A flywheel holding tool can be made out of an old junk flywheel ring gear and used in place of a strap wrench.

1. Using an abrasive cut-off wheel, cut out a six tooth segment of ring gear as shown.
2. Grind off any burrs or sharp edges.
3. Invert segment and place it between ignition bosses on crankcase so tool teeth engage flywheel ring gear teeth. Bosses will lock tool and flywheel in position for loosening, tightening, or removing with a puller.

ROCKER ARM/CRANKSHAFT TOOL



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

1. Find a used connecting rod from a 10 HP or larger engine. Remove and discard rod cap.
2. Remove studs of a Posi-Lock rod or grind off aligning steps of a Command rod, so joint surface is flat.
3. Find a 1 in. long capscrew with correct thread size to match threads in connecting rod.
4. Use a flat washer with correct I.D. to slip on capscrew and approximately 1 in. O.D. Assemble capscrew and washer to joint surface of rod.

TROUBLESHOOTING GUIDE

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

NOTE: An EFI engine will not operate without a battery connected to system.

Some general common causes of EFI engine troubles are listed below and vary by engine specification. Use these to locate causing factors.

Engine Cranks But Will Not Start

- Battery connected backwards.
- Blown fuses.
- Clogged fuel line or fuel filter.
- Empty fuel tank.
- Faulty ignition coil.
- Faulty spark plug.
- Fuel pump malfunction.
- Insufficient voltage to electronic control unit.
- Interlock circuit is engaged or faulty.
- Key switch or kill switch in OFF position.
- Quality of fuel (dirt, water, stale, mixture).
- Spark plug lead disconnected.

Engine Starts But Does Not Keep Running

- Faulty cylinder head gasket.
- Faulty or misadjusted throttle controls.
- Fuel pump malfunction.
- Intake leak.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Quality of fuel (dirt, water, stale, mixture).
- Restricted fuel tank cap vent.

Engine Starts Hard

- Clogged fuel line or fuel filter.
- Engine overheated.
- Faulty ACR mechanism.
- Faulty spark plug.
- Flywheel key sheared.
- Fuel pump malfunction.
- Interlock circuit is engaged or faulty.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Low compression.
- Quality of fuel (dirt, water, stale, mixture).
- Weak spark.

Engine Will Not Crank

- Battery is discharged.
- Faulty starter circuit.
- Faulty key switch or ignition switch.
- Interlock circuit is engaged or faulty.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Seized internal engine components.

Engine Runs But Misses

- Fuel system issue (Fuel Injector).
- Engine overheated.
- Faulty spark plug.
- Ignition coil faulty.
- Interlock circuit is engaged or faulty.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Quality of fuel (dirt, water, stale, mixture).
- Spark plug lead disconnected.
- Spark plug lead boot loose on plug.
- Spark plug lead loose.

Engine Will Not Idle

- Engine overheated.
- Faulty spark plug.
- Idle speed adjusting screw improperly set.
- Inadequate fuel supply.
- Low compression.
- Quality of fuel (dirt, water, stale, mixture).
- Restricted fuel tank cap vent.

Engine Overheats

- Cooling fan broken.
- Excessive engine load.
- Lean fuel mixture.
- Low crankcase oil level.
- Cooling system components clogged or restricted.

Engine Knocks

- Excessive engine load.
- Incorrect valve lash adjustment.
- Incorrect oil viscosity/type.
- Internal wear or damage.
- Low crankcase oil level.
- Quality of fuel (dirt, water, stale, mixture).
- Loose/worn pulley/clutch on crankshaft PTO.

Troubleshooting

Engine Loses Power

- Dirty air cleaner element (OEM supplied).
- Engine overheated.
- Excessive engine load.
- Restricted exhaust (OEM supplied).
- Faulty spark plug.
- High crankcase oil level.
- Incorrect governor setting (OEM supplied).
- Low battery.
- Low compression.
- Low crankcase oil level.
- Quality of fuel (dirt, water, stale, mixture).

Engine Uses Excessive Amount of Oil

- Loose or improperly torqued fasteners.
- Blown head gasket/overheated.
- Breather reed broken.
- Clogged, broken, or inoperative crankcase breather.
- Crankcase overfilled.
- Incorrect oil viscosity/type.
- Worn cylinder bore.
- Worn or broken piston rings.
- Worn valve stems/valve guides.

Oil Leaks from Oil Seals, Gaskets

- Breather reed broken.
- Clogged, broken, or inoperative crankcase breather.
- Loose or improperly torqued fasteners.
- Piston blow by, or leaky valves.
- Restricted exhaust (OEM supplied).

EXTERNAL ENGINE INSPECTION

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



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

- Check for buildup of dirt and debris on crankcase, cooling fins, screen, and other external surfaces. Dirt or debris on these areas can cause overheating.
- Check for obvious fuel and oil leaks, and damaged components. Excessive oil leakage can indicate a clogged or inoperative breather, worn or damaged seals or gaskets, or loose fasteners.
- Check air cleaner system (OEM supplied) for damage or indications of improper fit and seal.

- Check air cleaner element (OEM supplied). Look for holes, tears, cracked or damaged sealing surfaces, or other damage that could allow unfiltered air into engine. A dirty or clogged element could indicate insufficient or improper maintenance.
- Check throttle body throat for dirt. Dirt in throat is further indication that air cleaner was not functioning properly.
- Check if oil level is within operating range on dipstick. If it is above, sniff for gasoline odor.
- Check condition of oil. Drain oil into a container; it should flow freely. Check for metal chips and other foreign particles.

Sludge is a natural by-product of combustion; a small accumulation is normal. Excessive sludge formation could indicate over rich fuel settings, weak ignition, overextended oil change interval or wrong weight or type of oil was used.


CLEANING ENGINE


| | |
|---|--|
|  |  WARNING |
| | Cleaning Solvents can cause severe injury or death. Use only in well ventilated areas away from ignition sources. |
| Carburetor cleaners and solvents are extremely flammable. Follow cleaner manufacturer's warnings and instructions on its proper and safe use. Never use gasoline as a cleaning agent. | |

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

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

CRANKCASE VACUUM TEST

| | |
|---|--|
|  | <p>⚠ WARNING</p> <p>Carbon Monoxide can cause severe nausea, fainting or death.</p> <p>Avoid inhaling exhaust fumes.</p> |
| | <p>Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled.</p> |

| | |
|---|---|
|  | <p>⚠ WARNING</p> <p>Rotating Parts can cause severe injury.</p> <p>Stay away while engine is in operation.</p> |
| | <p>Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate engine with covers, shrouds, or guards removed.</p> |

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

Crankcase vacuum is best measured with either a water manometer or a vacuum gauge. Complete instructions are provided in kits.

To test crankcase vacuum with manometer:

1. Insert rubber stopper into oil fill hole. Be sure pinch clamp is installed on hose and use tapered adapters to connect hose between stopper and one manometer tube. Leave other tube open to atmosphere. Check that water level in manometer is at 0 line. Make sure pinch clamp is closed.
2. Start engine and run no-load high speed.
3. Open clamp and note water level in tube.
Level in engine side should be a minimum of 10.2 cm (4 in.) above level in open side.
If level in engine side is less than specified (low/no vacuum), or level in engine side is lower than level in open side (pressure), check for conditions in table below.
4. Close pinch clamp before stopping engine.

To test crankcase vacuum with vacuum/pressure gauge:

1. Remove dipstick or oil fill plug/cap.
2. Install adapter into oil fill/dipstick tube opening, upside down over end of a small diameter dipstick tube, or directly into engine if a tube is not used. Insert barbed gauge fitting into hole in stopper.
3. Run engine and observe gauge reading.
Analog tester—needle movement to left of 0 is a vacuum, and movement to right indicates a pressure.
Digital tester—depress test button on top of tester.
Crankcase vacuum should be a minimum of 10.2 cm (4 in.) of water. If reading is below specification, or if pressure is present, check table below for possible causes and conclusions.

| Condition | Conclusion |
|---|---|
| Crankcase breather clogged or inoperative. | <p>NOTE: If breather is integral part of valve cover and cannot be serviced separately, replace valve cover and recheck pressure.</p> <p>Disassemble breather, clean parts thoroughly, check sealing surfaces for flatness, reassemble, and recheck pressure.</p> |
| Seals and/or gaskets leaking. Loose or improperly torque fasteners. | Replace all worn or damaged seals and gaskets. Make sure all fasteners are tightened securely. Use appropriate torque values and sequences when necessary. |
| Piston blow by or leaky valves (confirm by inspecting components). | Recondition piston, rings, cylinder bore, valves and valves guides. |
| Restricted exhaust (OEM supplied). | Refer to equipment manufacturer's manual for information on exhaust system. |

Troubleshooting

COMPRESSION TEST

This engine is equipped with an automatic compression release (ACR) mechanism. It is difficult to obtain an accurate compression reading because of ACR mechanism. As an alternative, use cylinder leakdown test described below.

CYLINDER LEAKDOWN TEST

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

Cylinder leakdown tester is a relatively simple, inexpensive leakdown tester for small engines. This tester includes a quick-connect for attaching adapter hose and a holding tool.

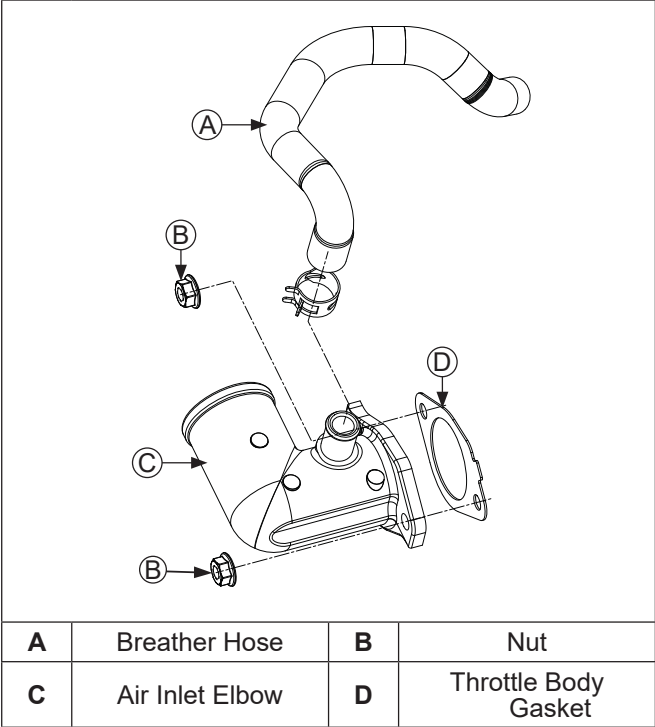
1. Run engine for 3-5 minutes to warm it up.
2. Remove spark plug and air filter from engine.
3. Rotate crankshaft until piston (of cylinder being tested) is at top dead center (TDC) of compression stroke. Hold engine in this position while testing. Holding tool supplied with tester can be used if PTO end of crankshaft is accessible. Lock holding tool onto crankshaft. Install a 3/8 in. breaker bar into hole/slot of holding tool, so it is perpendicular to both holding tool and crankshaft PTO.
If flywheel end is more accessible, use a breaker bar and socket on flywheel nut/screw to hold it in position. An assistant may be needed to hold breaker bar during testing. If engine is mounted in a piece of equipment, it may be possible to hold it by clamping or wedging a driven component. Just be certain that engine cannot rotate off of TDC in either direction.
4. Install adapter into spark plug hole, but do not attach it to tester at this time.
5. Turn regulator knob completely counterclockwise.
6. Connect an air source of at least 50 psi to tester.
7. Turn regulator knob clockwise (increase direction) until gauge needle is in yellow set area at low end of scale.
8. Connect tester quick-connect to adapter hose. While firmly holding engine at TDC, gradually open tester valve. Note gauge reading and listen for escaping air at combustion air intake, exhaust outlet, and crankcase breather.

| Condition | Conclusion |
|--|---|
| Air escaping from crankcase breather. | Ring or cylinder worn. |
| Air escaping from exhaust system. | Defective exhaust valve/improper seating. |
| Air escaping from intake. | Defective intake valve/improper seating. |
| Gauge reading in low (green) zone. | Piston rings and cylinder in good condition. |
| Gauge reading in moderate (yellow) zone. | Engine is still usable, but there is some wear present. Customer should start planning for overhaul or replacement. |
| Gauge reading in high (red) zone. | Rings and/or cylinder have considerable wear. Engine should be reconditioned or replaced. |

AIR CLEANER (OEM Supplied)

These systems are CARB/EPA certified and components should not be altered or modified in any way.
Refer to operating instructions of equipment this engine powers for specific air cleaner instructions.

Air Inlet Elbow Components



NOTE: Operating engine with loose or damaged air cleaner components could cause premature wear and failure. Replace all bent or damaged components.

Air Inlet Elbow

NOTE: Refer to equipment manufacturer's manual for air cleaner they supply.

1. Disconnect one end of breather hose from valve cover or air inlet elbow.
2. Remove nuts securing air inlet elbow to throttle body.
3. Remove air inlet elbow and gasket from mounting studs.

BREATHER TUBE


Ensure both ends of breather tube are properly connected.

AIR COOLING

| | |
|--|--|
| | WARNING |
| | Hot Parts can cause severe burns. Do not touch engine while operating or just after stopping. |
| | Never operate engine with heat shields or guards removed. |

Proper cooling is essential. To prevent over heating, clean screens, cooling fins, and other external surfaces of engine. Avoid spraying water at wiring harness or any electrical components. Refer to Maintenance Schedule.

EFI SYSTEM

| | |
|--|--|
|  | <p style="text-align: center;">⚠ WARNING</p> <p>Explosive Fuel can cause fires and severe burns.</p> <p>Do not fill fuel tank while engine is hot or running.</p> |
| | <p>Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.</p> |

NOTE: Engines in this application have in-tank fuel pump, EFI fuel filter, and all fuel lines supplied and installed by OEM. Refer to equipment manufacturer's manual for information on these components and before working on fuel system.

Typical electronic fuel injection (EFI) system and related components include:

- In-tank fuel pump (OEM supplied and installed).
- Fuel filter (OEM supplied and installed).
- High pressure fuel line (OEM supplied and installed).
- Fuel injector.
- Throttle body.
- Electronic control unit (ECU).
- Ignition coil.
- Engine temperature sensor.
- Throttle position sensor (TPS).
- Crankshaft position sensor.
- Oxygen sensor.
- Temperature/Manifold Absolute Pressure (TMAP) sensor.
- Wire harness assembly & affiliated wiring.
- 10 Amp fuse (ignition switch).
- 10 Amp fuse (battery power).
- Malfunction indicator light (MIL) - OEM supplied and installed).

FUEL RECOMMENDATIONS

Refer to Maintenance.

FUEL LINE (OEM Supplied)

Low permeation fuel line must be installed on all Kohler Co. engines to maintain EPA and CARB regulatory compliance.

OPERATION

NOTE: When performing voltage or continuity tests, avoid putting excessive pressure on or against connector pins. Pin probes (maximum diameter 0.81 mm (0.032 in.) approximately) are recommended for testing to avoid spreading or bending terminals.

EFI system is designed to provide peak engine performance with optimum fuel efficiency and lowest possible emissions. Ignition and injection functions are electronically controlled, monitored and continually corrected during operation to maintain ideal air/fuel ratio.

Central component of system is Electronic Control Unit (ECU) which manages system operation, determining best combination of fuel mixture and ignition timing for current operating conditions.

An in-tank fuel pump is used to move fuel from tank through a fuel filter and fuel line. Fuel pump regulates fuel pressure to a system operating pressure of 50 psi. Fuel is delivered through high pressure fuel line into injector, which injects fuel into intake port. ECU controls amount of fuel by varying length of time that injector is on. This can range from 2 to over 12 milliseconds depending on fuel requirements. Controlled injection of fuel occurs every other crankshaft revolution, or once for each 4-stroke cycle. When intake valve opens, air/fuel mixture is drawn into combustion chamber, where it is compressed, ignited, and burned.

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

- Engine temperature is greater than 40°C (104°F).
- Oxygen sensor has warmed sufficiently to provide a signal (minimum 400°C, 752°F).
- Engine operation is at a steady state (not starting, warming up, accelerating, etc.).

During closed loop operation ECU has ability to readjust temporary and learned adaptive controls, providing compensation for changes in overall engine condition and operating environment, so it will be able to maintain ideal air/fuel ratio. This system requires a minimum engine temperature of 40°C (104°F) to properly adapt. These adaptive values are maintained as long as ECU is not reset.

During certain operating periods such as cold starts, warm up, acceleration, high load, etc., a richer air/fuel ratio is required and system operates in an open loop mode. In open loop operation oxygen sensor output is used to ensure engine is running rich, and controlling adjustments are based on primary sensor signals and programmed maps only. This system operates open loop whenever three conditions for closed loop operation (above) are not being met.

ECU is brain or central processing computer of entire EFI system. During operation, sensors continuously gather data which is relayed through wiring harness to input circuits within ECU. Signals to ECU include: ignition (on/off), crankshaft position and speed (RPM), throttle position, engine temperature, intake air temperature, exhaust oxygen levels, manifold absolute pressure, and battery voltage.

ECU compares input signals to programmed maps in its memory to determine appropriate fuel and spark requirements for immediate operating conditions. ECU then sends output signals to set injector duration and ignition timing.

ECU continually performs a diagnostic check of itself, each sensor, and system performance. If a fault is detected, ECU can turn on a Malfunction Indicator Light (MIL) on equipment control panel, store fault code in its fault memory, and go into a default operating mode. Depending on significance or severity of fault, normal operation may continue. A technician can access stored fault code using a fault code diagnosis flashed out through MIL. An optional computer software diagnostic program is also available, refer to Tools and Aids.

ECU requires a minimum of 6.0 volts to operate.

To prevent engine over-speed and possible failure, a rev-limiting feature is programmed into ECU. If maximum RPM limit (4400) is exceeded, ECU suppresses injection signals, cutting off fuel flow. This process repeats itself in rapid succession, limiting operation to preset maximum.

Wiring harness used in EFI system connects electrical components, providing current and ground paths for system to operate. All input and output signaling occurs through two special all weather connectors that attach and lock to ECU. Connectors are Black and Grey and keyed differently to prevent being attached to ECU incorrectly.

Condition of wiring, connectors, and terminal connections is essential to system function and performance. Corrosion, moisture, and poor connections are as likely a cause of operating problems and system errors as an actual component. Refer to Electrical System for additional information.

EFI system is a 12 VDC negative ground system, designed to operate down to a minimum of 6.0 volts. If system voltage drops below this level, operation of voltage sensitive components such as ECU, fuel pump relay, ignition coil, and injector will be intermittent or disrupted, causing erratic operation or hard starting. A fully charged, 12 volt battery with a minimum of 350 cold cranking amps is important in maintaining steady and reliable system operation. Battery condition and state of charge should always be checked first when troubleshooting an operational problem.

Keep in mind that EFI-related problems are often caused by wiring harness or connections. Even small amounts of corrosion or oxidation on terminals can interfere with milliamp currents used in system operation.

Cleaning connectors and grounds will solve problems in many cases. In an emergency situation, simply disconnecting and reconnecting connectors may clean up contacts enough to restore operation, at least temporarily.

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

Crankshaft position sensor is essential to engine operation; constantly monitoring rotation and speed (RPM) of crankshaft. There are 23 consecutive teeth cast into flywheel. One tooth is missing and is used to reference crankshaft position for ECU.

When ignition is turned ON, ECU captures and records battery voltage. During engine start (cranking) voltage drops 2+ volts. When ECU receives voltage drop input, it then looks for a signal from crankshaft position sensor. During rotation, an AC voltage pulse is created within sensor for each passing tooth. ECU calculates engine speed from time interval between consecutive pulses. Gap from missing tooth creates an interrupted input signal, corresponding to specific crankshaft position near BDC for cylinder. This signal serves as a reference for control of ignition timing by ECU. Synchronization of inductive speed pickup and crankshaft position takes place during first two revolutions each time engine is started. Sensor must be properly connected at all times. If sensor becomes disconnected for any reason, engine will quit running.

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

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

Correct position of TPS is established and set at factory. Do not loosen TPS or alter mounting position unless absolutely required by fault code diagnosis. If TPS is loosened or repositioned, appropriate TPS Learn Procedure must be performed to re-establish baseline relationship between ECU and TPS.

Engine temperature sensor is used by system to help determine fuel requirements for starting (a cold engine needs more fuel than one at or near operating temperature).

Mounted on cylinder head, it has a temperature-sensitive resistor. Resistance changes with engine temperature, altering voltage sent to ECU. Using a table stored in its memory, ECU correlates voltage drop to a specific temperature. Using fuel delivery maps, ECU then knows how much fuel is required for starting at that temperature.

Temperature/Manifold Absolute Pressure (TMAP) sensor is an integrated sensor that checks both intake air temperature and manifold absolute pressure.

Intake Air Temperature control is a thermally sensitive resistor that exhibits a change in electrical resistance with a change in its temperature. When sensor is cold, resistance of sensor is high. As sensor warms up, resistance drops and voltage signal increases. From voltage signal, ECU can determine temperature of intake air.

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Purpose of sensing air temperature is to help ECU calculate air density. Higher air temperature less dense air becomes. As air becomes less dense ECU knows that it needs to lessen fuel flow to achieve correct air/fuel ratio. If fuel flow was not changed engine would become rich, possibly losing power and consuming more fuel.

Manifold Absolute Pressure check provides immediate manifold pressure information to ECU. TMAP sensor measures difference in pressure between outside atmosphere and vacuum level inside intake passage and monitors pressure in passage as primary means of detecting load. Data is used to calculate air density and determine engine's mass air flow rate, which in turn determines required ideal fueling. TMAP also stores instant barometric pressure reading when key is turned ON.

Oxygen sensor functions like a small battery, generating a voltage signal to ECU based upon difference in oxygen content between exhaust gas and an air reference signal.

Tip of sensor, protruding into exhaust gas, is hollow. Outer portion of tip is surrounded by exhaust gas, using a pumping current to maintain nominal air reference of approximately 21% oxygen in air reference chamber of sensor, differences between exhaust and air reference are sent using a generated voltage signal of up to 1.0 volt to ECU. Voltage signal tells ECU if engine is straying from ideal fuel mixture, and ECU then adjusts injector pulse accordingly.

Oxygen sensor functions after being heated to a minimum of 400°C (752°F). A heater inside sensor heats electrode to optimum temperature in about 10 seconds. Oxygen sensor receives ground through wire, eliminating need for proper grounding through muffler. If problems indicate a bad oxygen sensor, check all connections and wire harness. Oxygen sensor can also be contaminated by leaded fuel, certain RTV and/or other silicone compounds, fuel injector cleaners, etc. Use only those products indicated as O2 Sensor Safe.

Fuel injector mounts on throttle body and high pressure fuel line attaches to cap on fuel injector. Replaceable O-rings on both ends of injector prevent external fuel leakage and also insulate it from heat and vibration. A special clip connects injector and fuel injector cap. O-rings and retaining clip must be replaced any time fuel injector is separated from its normal mounting position.

When key switch is on, fuel pump will pressurize high pressure fuel line to 50 psi, and voltage is present at injector. At proper instant, ECU completes ground circuit, energizing injector. Valve needle in injector is opened electromagnetically, and pressure in high pressure fuel line forces fuel down through injector. Director plate at tip of injector contains a series of calibrated openings which directs fuel into intake passage in a cone-shaped spray pattern.

Injector has sequential fueling that opens and closes once every other crankshaft revolution. Amount of fuel injected is controlled by ECU and determined by length of time valve needle is held open, also referred to as injection duration or pulse width. Time injector is open (milliseconds) may vary in duration depending on speed and load requirements of engine.

A high-voltage, solid-state, battery ignition system is used with EFI system. ECU controls ignition output and timing through transistorized control of primary current delivered to coil. Based on input from crankshaft position sensor, ECU determines correct firing point for speed at which engine is running. At proper instant, it interrupts flow of primary current in coil, causing electromagnetic flux field to collapse. Flux collapse induces an instantaneous high voltage in coil secondary which is strong enough to bridge gap on spark plug. Coil fires every other revolution.

Equipment this engine powers has a starter generator, refer to equipment manufacturer's manual for charging system troubleshooting information.

An electric in-tank fuel pump (OEM supplied) is used to transfer fuel in EFI system. Fuel pump is regulated at 350 kilopascals (50 psi).

When key switch is turned ON and all safety switch requirements are met, ECU activates fuel pump for up to six seconds (prime process), which pressurizes system for start-up. If key switch is not promptly turned to start position, engine fails to start, or engine is stopped with key switch ON (as in case of an accident), ECU switches off pump preventing continued delivery of fuel. Once engine is running, fuel pump remains on.

A special EFI 10-micron filter (OEM supplied) is in fuel tank. Be sure to use an approved 10-micron filter for replacement. Refer to equipment manufacturer's manual for information.

High pressure fuel line assembly (OEM supplied) attaches to injector cap and fuel pump using connectors. High pressure fuel line feeds fuel to top of injector through injector cap.

Vent hose assembly (OEM supplied) is intended to vent fuel vapor out of fuel tank, through an OEM supplied carbon canister and then directs all fuel vapor into purge port located on throttle body.

EFI engines have no carburetor, so throttle function (regulate incoming combustion airflow) is achieved with a throttle valve in a separate throttle body attached to cylinder head/intake port/air inlet elbow. Throttle body provides mounting for fuel injector, throttle position sensor, TMAP sensor, high pressure fuel line, idle speed screw, and air inlet elbow.

Idle speed is only adjustment that may be performed on throttle body. Standard idle speed setting is 1050 RPM for pedal start applications or 1250 RPM for key start applications.

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

IMPORTANT NOTES!

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

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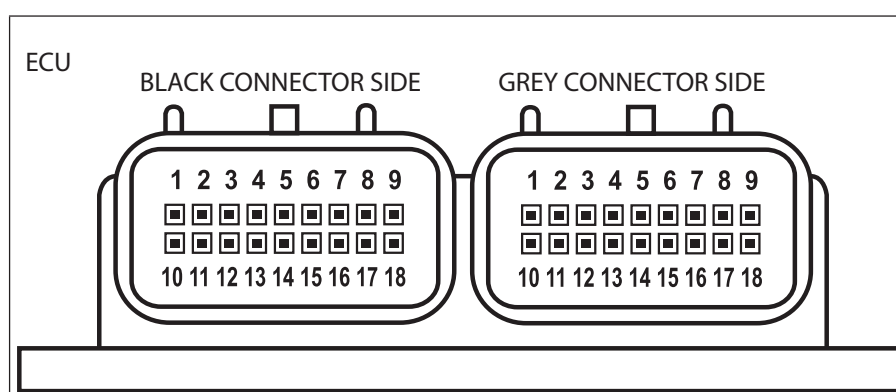
ELECTRICAL COMPONENTS

Electronic Control Unit (ECU)

Pinout of ECU

| Black Connector Side | |
|----------------------|--|
| Pin # | Function |
| 1 | Ignition Coil Ground |
| 2 | Battery Ground |
| 3 | Diagnostic Communication Line |
| 4 | Speed Sensor input |
| 5 | Fuel Injector Output Ground |
| 6 | Not Used |
| 7 | Oxygen Sensor Heater |
| 8 | Intake Air Temperature (TMAP) sensor input |
| 9 | Fuel Pump Ground |
| 10 | Ground for TPS, TMAP, O2 and Oil Sensors |
| 11 | Manifold Absolute Pressure (TMAP) sensor input |
| 12 | Throttle Position Sensor (TPS) input |
| 13 | Speed Sensor Ground |
| 14 | Engine Temperature Sensor input |
| 15 | Ignition Switch (Switched +12V) |
| 16 | Power for TPS and TMAP Sensors (+5V) |
| 17 | Oxygen Sensor (O2) input |
| 18 | Battery Power (Permanent +12V) |

| Grey Connector Side | |
|---------------------|--|
| Pin # | Description |
| 1 | Not Used |
| 2 | Not Used |
| 3 | Malfunction Indicator Light (MIL) Ground |
| 4 | Not Used |
| 5 | Not Used |
| 6 | Not Used |
| 7 | Not Used |
| 8 | Not Used |
| 9 | Battery Ground |
| 10 | Not Used |
| 11 | Not Used |
| 12 | Not Used |
| 13 | Not Used |
| 14 | Safety Switch Ground |
| 15 | Not Used |
| 16 | ECU |
| 17 | Fuel Pump Control (+12V) |
| 18 | Not Used |



Pinout of ECU

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

All operating and control functions within ECU are preset. No internal servicing or readjustment may be performed. If a problem is encountered, and you determine ECU to be faulty, contact your source of supply.

ECU pins are coated at factory with a thin layer of electrical grease to prevent fretting and corrosion. Do not attempt to remove grease from ECU pins.

Relationship between ECU and throttle position sensor (TPS) is very critical to proper system operation. If TPS or ECU is changed, or mounting position of TPS is altered, appropriate TPS Learn Procedure must be performed to restore synchronization.

Any service to ECU, TPS/Throttle Body (including idle speed increase over 300 RPM), or fuel pump replacement should include ECU Reset.

This will clear all trouble codes, all closed loop learned offsets, all max values, and all timers besides permanent hour meter.

This system will NOT reset when battery is disconnected!

ECU Reset Procedure

1. Turn key/ignition OFF.
2. Install Red wire jumper from Kohler EFI service kit on to service port (connect white wire to black wire in 4 way diagnostic port).
3. Turn key/ignition ON, then OFF and count 15 seconds.
4. Turn key/ignition ON, then OFF and count to 15 seconds a second time.
5. Remove Red wire jumper. Turn key/ignition ON, then OFF and count to 15 seconds a third time. ECU is reset.

A TPS Learn Procedure **must** be performed after ECU Reset. Follow TPS Learn Procedure for appropriate specific application being serviced.

TPS Learn Procedure for Pedal Start Applications

NOTE: Refer to equipment manufacturer's manual for details on throttle body cover and throttle cable removal/reinstallation.

1. Remove throttle body cover.
2. Disconnect throttle cable from throttle lever.
3. Turn idle screw clockwise one full turn prior to key/ignition ON after ECU Reset.
4. Start engine, run at low idle until engine is warm.
5. Idle speed must be above 1100 RPM. If below 1100 RPM, turn idle screw up to 1200 RPM and then shut down engine and perform ECU Reset again.
6. Restart engine, adjust idle speed down to 1050 RPM. Allow engine to dwell at 1050 RPM for about 3 seconds.
7. Turn key/ignition OFF and count to 15 seconds.
8. Reinstall throttle cable.
9. Reinstall throttle body cover.

Learn procedure for pedal start application is complete.

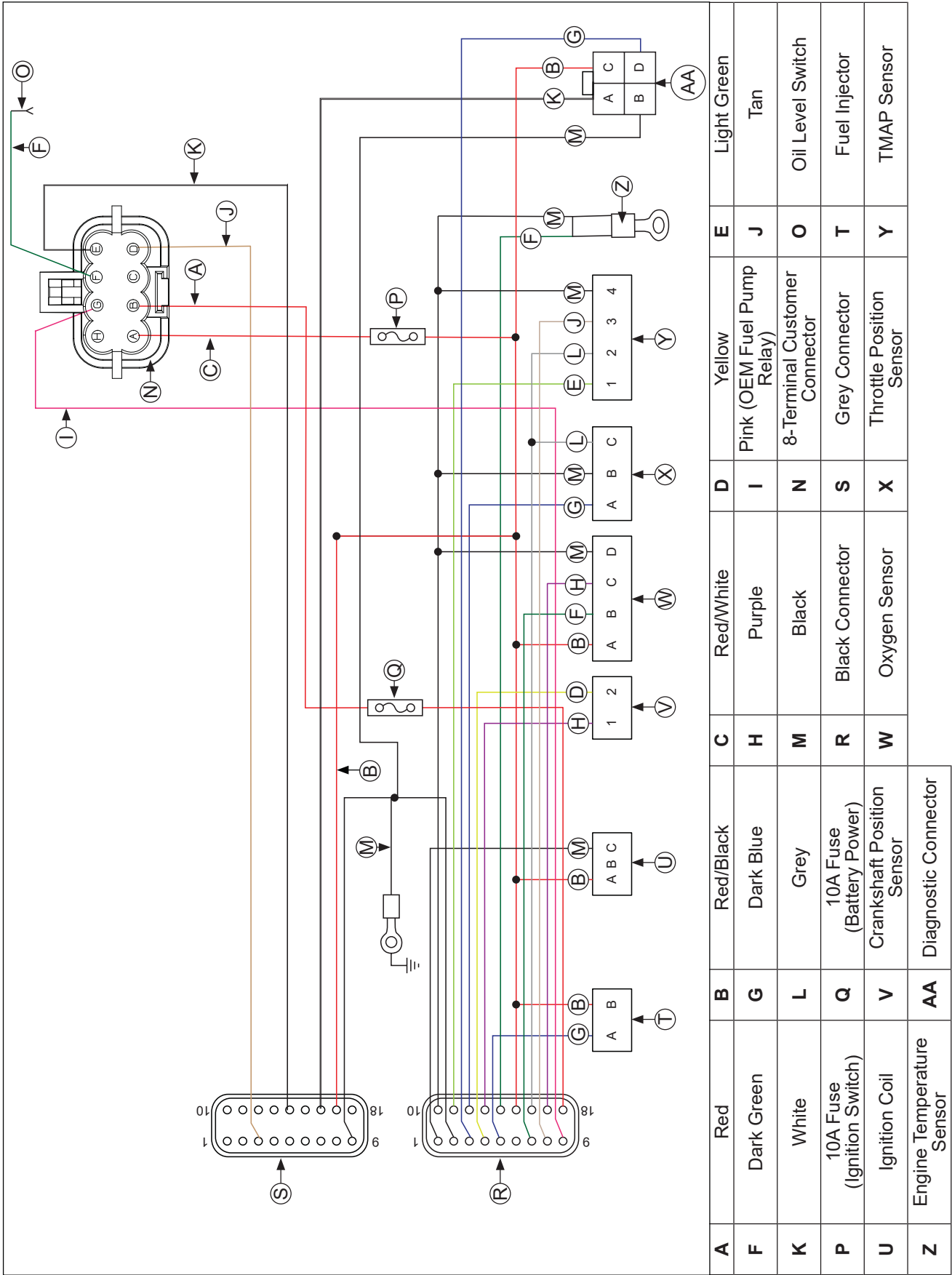
TPS Learn Procedure for Key Start Applications

1. Turn idle screw clockwise one full turn prior to key/ignition ON after ECU Reset.
2. Start engine, run at low idle until engine is warm.
3. Idle speed must be above 1200 RPM. If below 1200 RPM, turn idle screw up to 1300 RPM and then shut down engine and perform ECU Reset again.
4. Restart engine, adjust idle speed down to 1250 RPM. Allow engine to dwell at 1250 RPM for about 3 seconds.
5. Turn key/ignition OFF and count to 15 seconds.

Learn procedure for key start application is complete.

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Wiring Diagram



Crankshaft Position Sensor

A sealed, non-serviceable assembly. If fault code P0337 is present and engine does not start/run, proceed to step 1. If P0337 is present and engine operates, clear codes and retest. If Fault Code diagnosis indicates a problem within this area, test and correct as follows.

- 1. Inspect wiring and connections for damage or problems.
- 2. Make sure engine has resistor type spark plug.
- 3. Disconnect Black connector from ECU.
- 4. Connect an ohmmeter between #4 and #13 pin terminals. A resistance value of 325-395 Ω at room temperature (20°C, 68°F) should be obtained. If resistance is correct, remove blower housing to check sensor mounting, flywheel teeth (damage, run-out, etc.), and flywheel key. Follow procedures in Disassembly to remove blower housing.
- 5. Disconnect crankshaft position sensor connector from wiring harness. Test resistance between terminals. A reading of 325-395 Ω should again be obtained.
 - a. If resistance is incorrect, remove screw securing sensor to bracket and replace sensor.
 - b. If resistance in step 4 was incorrect, but resistance of sensor alone was correct, test wire harness circuits between sensor connector terminals and corresponding pin terminals (#4 and #13) in main connector. Correct any observed problem, reconnect sensor, and perform step 4 again.
- 6. When fault is corrected and engine starts, clear fault codes following ECU Reset procedure.

Throttle Position Sensor (TPS)

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

Diagnostics of sensor: ECU will have electrical faults captured in fault codes P0122 and P0123. Fault code P0122 detecting low voltage, open circuit, and P0123 for high voltage conditions between ECU, wire harness, and sensor. Tip: when working with any electrical connection, remember to keep connections clean & dry. This is best accomplished by cleaning connection thoroughly prior to disassembly. Contaminated sensor connections can cause premature engine faults. Functionally testing sensor cannot be done with simple resistance checks. If either of these two faults is present or a TPS fault is suspected, recommended diagnostic test is as follows:

If a computer with diagnostic software is available

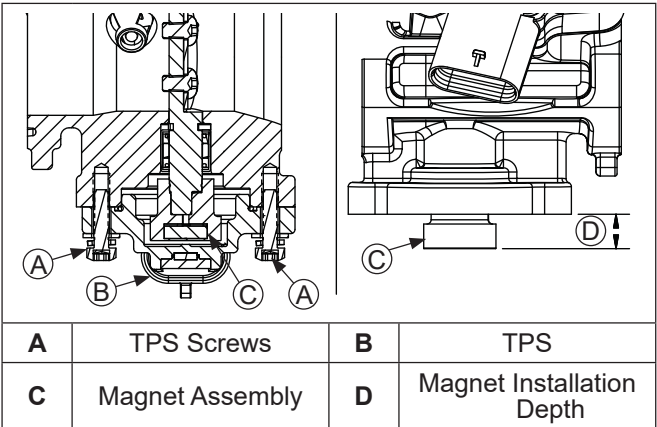
Observe throttle percent and raw TPS values through diagnostic software. With diagnostic software communicating to ECU and key ON engine not running, these values can be observed while throttle is moved from closed to full open position. There should be a smooth and repeatable throttle percent value starting at closed position reading between 0 and 3% to WOT position reading of 93 to 100%. If one of these values is outside of specified range and output transitions in a smooth manner, reset ECU and run test again.

Since there is no longer any wear elements inside sensor, most likely faults will be in electrical connections between sensor and wire harness and wire harness to ECU. With service software communicating to ECU and engine not running, a small load or gentle back and forth motion can be applied to connectors or wires just outside connectors to detect a faulty connection.

If only a volt meter is available

Measure voltage supply to sensor from ECU. This voltage should be 5.00 +/- 0.20 volts. This can be measured by gently probing terminals B & C on harness side with TPS connector removed from TPS and key ON. This will generate a P0122 fault that can be cleared with an ECU reset. If voltage is low, battery, harness and ECU should be investigated. If supply voltage is good, plug sensor back into harness. Probe sensor signal wire with volt meter, terminal A at TPS or pin Black 12 at ECU. This signal should start between 0.6-1.2 volts at low idle and grow smoothly as throttle is opened to 4.3-4.8 volts at full open (WOT). Since there is no longer any wear elements inside sensor, most likely faults will be in electrical connections between sensor and wire harness and wire harness to ECU.

Replace TPS



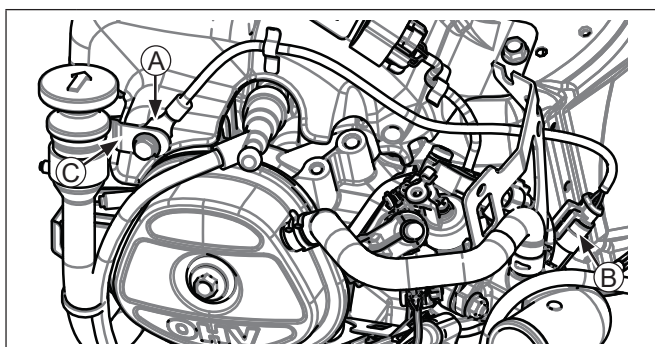
Magnet assembly is captured in a small plastic housing that is press fit to end of throttle shaft. If replacement is required, it can be replaced as follows:

- 1. Remove screws securing TPS to throttle body. Remove sensor from throttle body, exposing round magnet assembly.
- 2. A pair of flat blade screw drivers or a spanner tool can be used to pry this off shaft. Caution should be used to avoid damage to machined flat surface that sensor seals against. Also, make sure throttle blade is in full open position to avoid driving throttle blade into throttle bore causing damage to blade and/or bore.
- 3. When replacing magnet assembly, alignment is critical. There is a D-shaped drive feature on end of shaft and a matching pocket in magnet assembly. On outer diameter of magnet assembly is a notch that aligns with center of flat feature of D. Align this notch and flat of D feature in shaft and preassemble parts.

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4. With throttle blade in full open position (WOT), press magnet assembly fully on to throttle shaft. Full insertion can be checked by measuring height from throttle body sensor mounting face to end of magnet assembly. This should be no more than 8.6 mm (0.34 in.). Installation process requires significant force, so take care that all parts are aligned. Tapping magnet assembly on can fracture/damage brittle magnet within assembly and throttle body assembly and is **NOT RECOMMENDED**.
5. Install sensor and secure with screws. Torque screws to 1.3 N·m (11.5 in. lb.).

Engine Temperature Sensor



| | |
|----------|---------------------------|
| A | Engine Temperature Sensor |
| B | Unplug Sensor to Replace |
| C | Dipstick Tube Bracket |

NOTE: Engine temperature sensor resembles a ground wire.

A sealed, serviceable assembly. A faulty sensor requires replacement. If a fault code indicates a problem with temperature sensor, it can be tested as follows:

1. Shut off engine and allow it to return to room temperature (25°C, 77°F).
2. With sensor still connected, check temperature sensor circuit resistance between Black pin 10 and 14 terminals. Value should be 9000-11000 Ω.
3. If resistance is out of specifications, unplug sensor from wiring harness and replace. Note that sensor is installed under dipstick tube bracket.

Temperature/Manifold Absolute Pressure (TMAP) Sensor

A sealed non-serviceable integrated sensor that checks both intake air temperature and manifold absolute pressure. Complete replacement is required if it is faulty. Sensor and wiring harness can be checked as follows.

If a fault code indicates a problem with Intake Air Temperature (TMAP) Sensor Circuit (P0112 or P0113), it can be tested as follows:

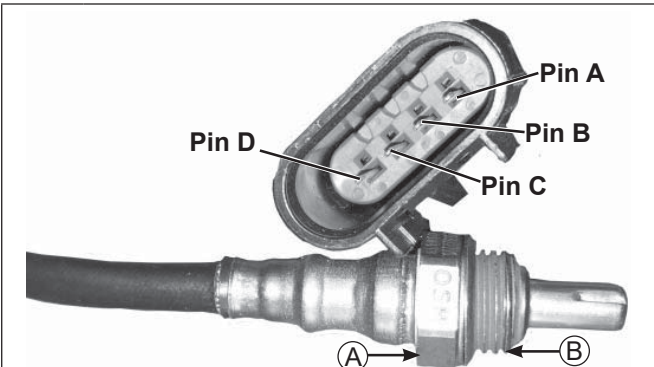
1. Remove TMAP sensor from throttle body.
2. Allow it to reach room temperature (20°C, 68°F).
3. Unplug Black connector from ECU.
4. With sensor still connected, check temperature sensor circuit resistance between Black pin 10 and 8 pin terminals. Value should be 1850-2450 Ω.
5. Unplug sensor from wire harness and check sensor resistance separately across pin. Resistance value should again be 1850-2450 Ω.
 - a. If resistance is out of specifications, check local temperature. Sensor resistance will go down as temperature is higher. Replace TMAP sensor if determined to be faulty.
 - b. If it is within specifications, proceed to Step 6.
6. Check circuits (input, ground), from main harness connector to sensor plug for continuity, damage, etc. Connect one ohmmeter lead to Black pin 8 in main harness connector (as in step 4). Connect other lead to terminal #3 in sensor plug. Continuity should be indicated. Repeat test between Black pin 10 and terminal #4 in sensor plug.
7. Reinstall sensor.

If a fault code indicates a problem with Manifold Absolute Pressure (TMAP) Sensor Circuit (P0107 or P0108), it can be tested as follows:

1. Make sure all connections are making proper contact and are free of dirt and debris. Slide locking tab out and pull off TMAP connector. Turn key switch to ON and check with a volt meter by contacting red lead to pin 1 and black lead to pin 2. There should be 5 volts present, indicating ECU and wiring harness are functioning.
2. Check continuity in wire harness. Ohms between Pin 3 at sensor connector and Black pin 11 connector at ECU should be near zero ohms. If no continuity is measured or very high resistance, replace wire harness.
3. Check to make sure throttle body is not loose and TMAP sensor is not loose. Loose parts would allow a vacuum leak, making TMAP sensor report misleading information to ECU.
 - a. Tighten all hardware and perform an ECU Reset and a TPS Learn Procedure to see if MIL will display a fault with sensor again. If MIL finds a fault with TMAP sensor, replace it.

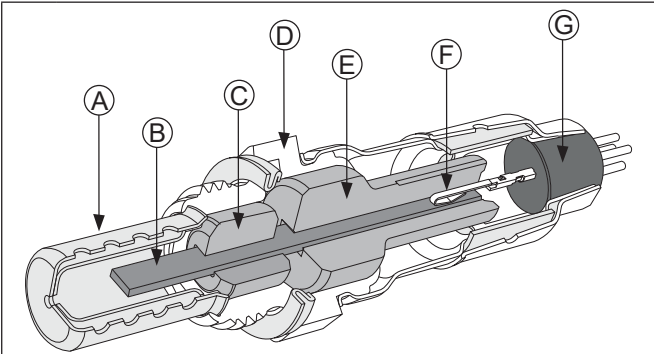
Oxygen Sensor (O2)

Detail



| | | | |
|--|-------------------------------|--------------|---------------------------|
| Pin A | Purple Wire, Heater + | Pin B | White Wire, Heater - |
| Pin C | Grey Wire, Sensor Output | Pin D | Black Wire, Sensor Ground |
| A | 14 mm or 9/16 in. Wrench Size | B | 12 mm x 1.25 Thread Size |
| Installation Torque 18 N·m (159 in. lb.) | | | |

Cutaway Oxygen Sensor (O2) Components



| | | | |
|----------|----------------------|----------|--------------------------------|
| A | Protection Shield | B | Planar Element and Heater |
| C | Lower Insulator | D | Stainless Steel Housing |
| E | Upper Insulator | F | Terminal Connection to Element |
| G | High Temp Water Seal | | |

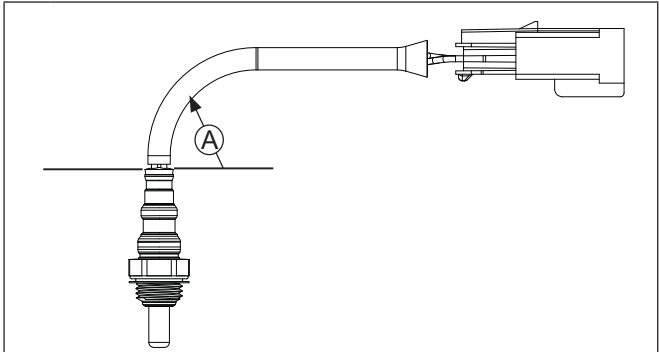
Temperature must be controlled very accurately and gas constituents measured to a high degree of accuracy for absolute sensor measurements. This requires laboratory equipment to determine a good or bad sensor in field. Furthermore, as with most devices, intermittent problems are difficult to diagnose. Still, with a good understanding of system and sensor, it is possible to diagnose many sensor problems in field.

Using diagnostic software connected to ECU is a useful technique for observing sensor performance. However, user must understand that such software reads a signal generated by ECU. If there is an ECU or wiring problem, readings could be misinterpreted as a sensor problem. Digital nature of signal to software means that it is not reading continuous output of sensor. A voltmeter can also be used as an effective tool in diagnosing sensors.

It is advisable to use an electronic meter such as a digital voltmeter. Simple mechanical meters may place a heavy electrical load on sensor and cause inaccurate readings. Since resistance of sensor is highest at low temperatures, such meters will cause largest inaccuracies when sensor is in a cool exhaust.

Visual Inspection

Sensor Wire Detail



A Keep a minimum of 25 mm (1.0 in.) radius at grommet.

NOTE: Always route harness away from hot exhaust and away from moving parts.

NOTE: **Do not attempt to clean sensor.** Replace as needed.

1. Look for a damaged or disconnected sensor-to-engine harness connection.
2. Look for damage to sensor lead wire or associated engine wiring due to cutting, chaffing or melting on a hot surface.
3. Disconnect sensor connector and look for corrosion in connector.
4. Try reconnecting sensor and observe if problem has cleared.
5. Correct any problems found during visual check.
6. Inspect for any exhaust system leaks upstream or downstream of oxygen sensor. Confirm oxygen sensor is secured to 18 N·m (159 in. lb.).

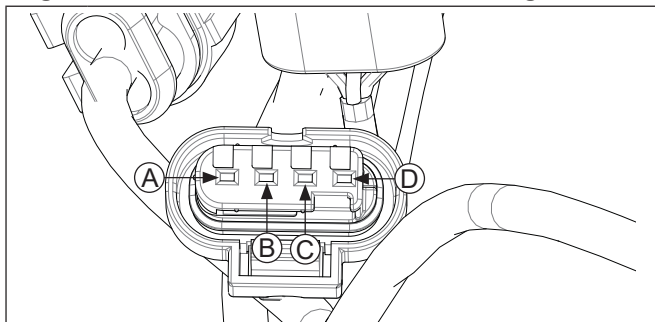
All leaks must be repaired and an ECU/TPS reset must be performed before proceeding with sensor testing.

7. Using diagnostic software, document any trouble codes. Determine if historic trouble codes are logically related to current fault experienced. If uncertain, clear codes and retest.

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Sensor Signal Observation

Engine Harness O2 Sensor Connector Plug Detail



| | | | |
|----------|--------------------|----------|------------|
| A | Red w/Black Stripe | B | Dark Green |
| C | Purple | D | Black |

NOTE: Do not cut into or pierce sensor or engine wiring to make this connection. Sensor produces a very small signal. Corrosion or damage to wiring could lead to an incorrect signal because of repairs or contamination to sensor.

1. With sensor connected and using diagnostic software, start engine to observe O2 sensor activity. Run engine at sufficient speed to bring sensor and engine up to operating temperature (engine temperature of 150°F (66°C) or more displayed by diagnostic software).

Maintained throttle openings of less than 37% typically display closed loop operation where sensor output voltage should cycle between 0.05 to 0.95 Volts.

Maintained throttle openings of 38-50% and above typically display open loop operation where sensor should have above 0.500 Volt. Occasional spikes outside these values is normal. Lack of continuous fluctuation is not an indication of a defective sensor.

2. With key ON and engine OFF, sensor connected, using diagnostic software, O2 volts displayed should be more than 1.0 volt. This voltage is generated by ECU. If not present, there may be a power and/or ground supply fault to engine harness or ECU, a fault of engine harness itself (refer to Visual Inspection), or a fault of ECU.

With key ON and sensor unplugged, using a digital voltmeter, observe voltage between Pin socket C and Pin socket D of engine wiring harness (refer to engine harness connector plug detail at top of page). Voltage should read approximately 5.0 volts.

3. Using a digital voltmeter, observe system sensor voltage between Pin socket A and negative (-) battery ground. Battery voltage should be seen. If battery voltage is not seen, inspect engine wiring, fuses, and/or electrical connections.

Removal Inspection

NOTE: Apply anti-seize compound only to threads.

Anti-seize compound will affect sensor performance if it gets into lower shield of sensor.

1. If sensor has heavy deposits on lower shield, engine, oil, or fuel may be source.
2. If heavy carbon deposits are observed, incorrect engine fuel control may be occurring.
3. With sensor at room temperature, measure heater circuit resistance, purple wire (Pin A) and white wire (Pin B).

Resistance should be 16.5-19.5 Ω .


4. If a damaged sensor is found, identify root cause, which may be elsewhere in application. Refer to Troubleshooting-Oxygen (O2) Sensor table.
5. A special "dry to touch" anti-seize compound is applied to all new oxygen sensors at factory. If recommended mounting thread sizes are used, this material provides excellent anti-seize capabilities and no additional anti-seize is needed. If sensor is removed from engine and reinstalled, anti-seize compound should be reapplied. Use an oxygen sensor safe type anti-seize compound. It should be applied according to directions on label. Torque sensor to 18 N·m (159 in. lb.).

Troubleshooting-Oxygen (O2) Sensor

| Condition | Possible Cause | Conclusion |
|---|---|---|
| Continuous low voltage output (less than 400mV) observed with throttle openings of 38-50% or more. Fault codes P0131, P0171, or P0174 may set. | Shorted sensor or sensor circuit. Shorted lead wire. Wiring shorted to ground. | Replace sensor or replace and properly route wiring. |
| | Upstream or downstream exhaust leaks observed. Air leak at sensor. | Repair all exhaust leaks and torque sensor to 18 N·m (159 in. lb.). |
| | Restricted fuel supply. | Resolve fuel supply issues from tank to engine. Test fuel pressure. Perform repairs necessary. |
| | Misfire | A misfire causing incomplete combustion will result in lean (low voltage) values. |
| | Sensor failure-stuck lean. | Replace sensor. |
| Continuous high voltage output (600mV or more) observed with throttle openings of 37% or less. Fault codes P0172 or P0132 may set. | Silica poisoning. | Replace sensor. Identify and resolve root cause. |
| | Contaminated gasoline. | Purge fuel system and retest. |
| | Wiring shorted to voltage. | Replace damaged harness. |
| | Overly rich condition due to unmetered fuel entering combustion chamber. | Test fuel pressure. Inspect fuel pump vent and evaporative emissions hoses for raw fuel flow. Inspect engine oil for fuel contamination; drain and refill if suspect. Perform repairs as necessary. |
| | Cold engine. Engine temperature below 150°F (66°C) as displayed by diagnostic software. | Normal operation, or engine operated in an excessively cold environment. |
| No activity from sensor. Diagnostic software displays 1.015 Volts continuously. Fault codes P0031 or P0032 may set. | Sensor failure-stuck rich. | Replace sensor. |
| | Heater circuit open or shorted. | Replace sensor. |
| | Engine keyed ON with sensor disconnected. Historic codes. | Secure and/or confirm sensor connection and clear codes. |
| | Contaminated gasoline. | Purge fuel system and retest. |
| | Broken wire. Damaged sensor. | Replace sensor. |

EFI SYSTEM

Fuel Injector



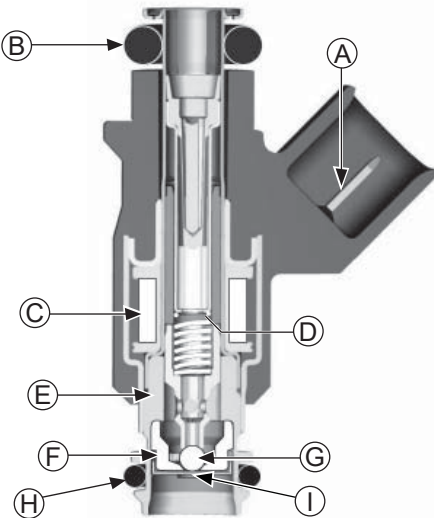
⚠ WARNING

Explosive Fuel can cause fires and severe burns.

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

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.

Details



| | | | |
|---|-----------------------|---|--------------|
| A | Electrical Connection | B | Upper O-ring |
| C | Solenoid Winding | D | Armature |
| E | Valve Housing | F | Valve Seat |
| G | Valve End | H | Lower O-ring |
| I | Director Plate | | |

NOTE: Do not apply voltage to fuel injector. Excessive voltage will burn out injector. Do not ground injector with ignition ON. Injector will open/turn on if relay is energized.

NOTE: When cranking engine with injector disconnected, fault codes will be registered in ECU and will need to be cleared using software fault clear or an ECU Reset and TPS Learn Procedure.

Injector problems typically fall into three general categories: electrical, dirty/clogged, or leakage. Injector problems due to dirt or clogging are generally unlikely due to design of injector, high fuel pressure, and detergent additives in gasoline. Symptoms that could be caused by dirty/clogged injector include rough idle, hesitation/stumbling during acceleration, or triggering of fault codes related to fuel delivery.

Injector clogging is usually caused by a buildup of deposits on director plate, restricting flow of fuel, resulting in a poor spray pattern. Some contributing factors to injector clogging include higher than normal operating temperatures, short operating intervals, and dirty, incorrect, or poor quality fuel.

Cleaning of clogged injector is not recommended; it should be replaced. Additives and higher grades of fuel can be used as a preventative measure if clogging has been a problem.

An electrical problem usually will cause injector to stop functioning. Several methods may be used to check if injector is operating.

- With engine running at idle, listen for a buzzing or clicking sound.
- Disconnect electrical connector from injector and engine should stop running. If engine continues to run, disconnect vent line at air cleaner base. If engine continues to run, injector is suspect.

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

- Disconnect electrical connector from injector. Plug a 12 volt noid light into connector.
- Make sure all safety switch requirements are met. Crank engine and check for flashing of noid light.
 - If flashing occurs, use an ohmmeter (Rx1 scale) and check resistance of injector across two terminals. Proper resistance is 11-13 Ω. If injector resistance is correct, check whether connector and injector terminals are making a good connection. If resistance is not correct, replace injector.

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

Injector leakage is very unlikely, but in those rare instances it can be internal (past tip of valve needle), or external (weeping around injector O-ring). Loss of system pressure from leakage can cause hot restart problems and longer cranking times. Refer to Disassembly for removal of injector.

- Remove throttle body from engine leaving TPS, high pressure fuel line, injector and fuel line connections intact. Discard old gaskets.
- Position throttle body over an appropriate container to capture fuel and turn key switch ON to activate fuel pump and pressurize system. Do not turn switch to START position.
- If injector exhibits leakage of more than two to four drops per minute from tip, or shows any sign of leakage around outer shell, turn ignition switch OFF and replace injector as follows.
- Depressurize fuel system and disconnect high pressure fuel line from fuel injector cap.
- Clean any dirt accumulation from sealing/mounting area of faulty injector and disconnect electrical connector.

6. Pull retaining clip to separate fuel injector cap/ bracket assembly from injector. Remove screw holding fuel injector cap/bracket assembly to throttle body. Lift injector from throttle body.
7. Reverse appropriate procedures to install new injector and reassemble engine. Use new O-ring and retaining clip any time an injector is removed (new replacement injector includes new O-rings and retaining clip). Lubricate O-rings lightly with clean engine oil. Use installation tool provided with O-rings to install new upper O-ring. Place tool into fuel injector inlet. Place one side of O-ring into O-ring groove and roll O-ring over tool onto fuel injector. Torque screw securing fuel injector cap to 7.3 N·m (65 in. lb.). An ECU Reset and TPS Learn Procedure will need to be completed.

Ignition Coil

If coil is determined to be faulty, replacement is necessary. An ohmmeter may be used to test wiring and coil windings.

NOTE: Do not ground coil with ignition ON as it may overheat or spark.

NOTE: Always disconnect spark plug lead from spark plug before performing following tests.


NOTE: **If ignition coil is disabled and an ignition fault is registered, system will automatically disable corresponding fuel injector drive signal.** Fault must be corrected to ignition coil and ECU power (switch) must be turned OFF for 15 seconds for injector signal to return. This is a safety measure to prevent bore washing and oil dilution.

Testing

Using an ohmmeter set on Rx1 scale, check resistance in circuit as follows:

1. To check ignition coil, disconnect Black connector from ECU and test between Black pins 1 and 15. Wiring and coil primary circuit is OK if reading is 0.85-1.15 Ω .
2. If reading is not within specified range, check and clean connections and retest.
3. If reading is still not within specified range, test coil separately from main harness as follows:
 - a. Remove mounting screw retaining coil and disconnect primary lead connector.
 - b. Connect an ohmmeter set on Rx1 scale to primary terminal of coil. Primary resistance should be 0.5-0.8 Ω .
 - c. Connect an ohmmeter set on Rx10K scale between spark plug boot terminal and B+ primary terminal. Secondary resistance should be 6400-7800 Ω .
 - d. If either primary or secondary resistance is not within specified range, coil is faulty and needs to be replaced.

FUEL COMPONENTS

| | |
|---|---|
|  | ⚠ WARNING |
| | Explosive Fuel can cause fires and severe burns. Do not fill fuel tank while engine is hot or running. |
| | Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent. |

NOTE: Engines in this application have in-tank fuel pump, EFI fuel filter, and all fuel lines supplied and installed by OEM. Refer to equipment manufacturer's manual for information on these components and before working on fuel system.

In-Tank Fuel Pump (OEM Supplied and Installed)

Refer to equipment manufacturer's manual for information. Use only original equipment replacement parts.

High Pressure Fuel Line (OEM Supplied and Installed)

No specific servicing is required unless operating conditions indicate that it needs replacement. Thoroughly clean area around all joints and relieve any pressure before starting any disassembly. Refer to equipment manufacturer's manual for information. Use only original equipment replacement parts.

Vent Hose Assembly (OEM Supplied and Installed)

Purge port is located on throttle body by TMAP sensor and no specific servicing is required. No specific servicing is required for vent hose assembly (OEM supplied) unless operating conditions indicate replacement is required. Use only original equipment replacement parts. Visit KohlerEngines.com for recommended Kohler replacement parts; refer to equipment manufacturer's manual for replacement part information.

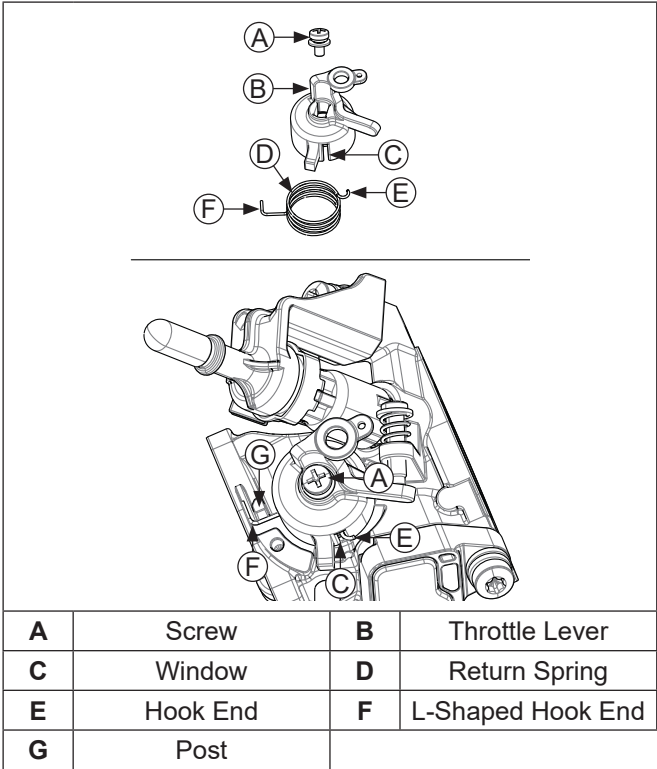
EFI SYSTEM

Throttle Body Assembly

NOTE: ECU Reset is required if throttle body is replaced.

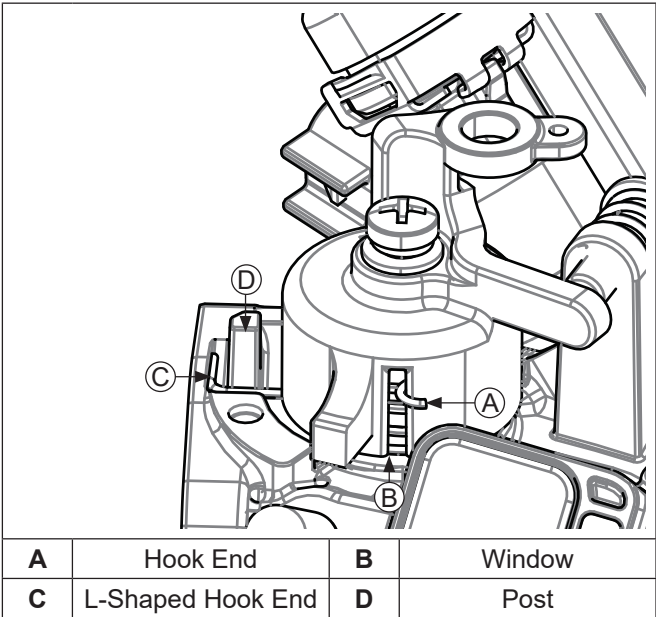
Throttle body is serviced as an assembly, with throttle shaft, TPS, throttle plate, TMAP sensor, fuel injector/cap/ bracket assembly, return spring, and idle speed adjusting screw installed. Throttle shaft rotates on needle bearings (non-serviceable), capped with seals to prevent air leaks.

NOTE: If return spring is replaced, proper placement of each hook end is required. Take note of each hook end before removing screw securing throttle lever.



1. Remove screw, throttle lever, and return spring.
2. Insert hook end of return spring in window of throttle lever and hold in place.
3. Hold throttle plate closed while positioning L-shaped hook end of return spring on post; holding throttle lever at slight angle, install throttle lever/spring assembly onto throttle shaft. A slight clockwise spring load rotation is required to align lever onto shaft.

4. Check that hook is in upper 1/3 to 1/2 of window in throttle lever. If hook is further down in window, wire is bound and steps 2 and 3 should be repeated.



5. When hook end is in proper position, install screw to secure throttle lever to shaft. Torque screw to 1.3 N·m (11.5 in. lb.).

TROUBLESHOOTING

Troubleshooting Guide


| Condition | Possible Cause |
|---|--|
| Engine Starts Hard or Fails to Start When Cold. | Fuel pump not running. |
| | Empty fuel tank. |
| | Faulty spark plug. |
| | Old/stale fuel. |
| | Incorrect fuel pressure. |
| | Crankshaft position sensor loose or faulty. |
| | TPS set incorrect (ECU Reset and TPS Learn). |
| | TPS faulty. |
| | Engine temperature sensor faulty. |
| | Faulty coil. |
| | Low system voltage. |
| | Faulty injector. |
| | Faulty battery. |
| | Loose or corroded connections. |
| Engine Starts Hard or Fails to Start When Hot. | Faulty spark plug. |
| | Fuel pump not running. |
| | Fuel pressure low. |
| | Insufficient fuel delivery. |
| | TPS set incorrect (ECU Reset and TPS Initialization). |
| | Crankshaft position sensor loose or faulty. |
| | TPS faulty. |
| | Engine temperature sensor faulty. |
| | Faulty injector. |
| Engine Stalls or Idles Roughly (cold or warm). | Faulty spark plug. |
| | Insufficient/excessive fuel delivery. |
| | TPS set incorrect. |
| | TPS faulty. |
| | Faulty engine temperature sensor. |
| | Faulty injector. |
| Engine Misses, Hesitates, or Stalls Under Load. | Fuel injector, fuel filter, fuel line, or fuel pick-up dirty/restricted. |
| | Dirty air cleaner. |
| | Insufficient fuel pressure or fuel delivery. |
| | Vacuum (intake air) leak. |
| | Improper governor setting, adjustment or operation. |
| | TPS/TMAP faulty, mounting problem or TPS Initialization Procedure incorrect. |
| | Bad coil, spark plug, or wires. |

EFI SYSTEM

Troubleshooting Guide

| Condition | Possible Cause |
|-----------|--|
| Low Power | Faulty/malfunctioning ignition system. |
| | Dirty air filter. |
| | Insufficient fuel delivery. |
| | Improper governor adjustment. |
| | Plugged/restricted exhaust. |
| | Basic engine problem exists. |
| | TPS faulty or mounting exists. |
| | Throttle plate in throttle body not fully opening to WOT stop (if equipped). |

Function Test

| | |
|--|--|
| |  WARNING |
| | High Pressure Fluids can puncture skin and cause severe injury or death. |
| | Do not work on fuel system without proper training or safety equipment. |
| Fluid puncture injuries are highly toxic and hazardous. If an injury occurs, seek immediate medical attention. | |

Function of fuel system is to provide sufficient delivery of fuel at system operating pressure of 50 psi ± 3. If an engine starts hard, or turns over but will not start, it may indicate a problem with EFI fuel system. A quick test will verify if system is operating.

1. Disconnect and ground spark plug lead.
2. Complete all safety interlock requirements and crank engine for approximately 3 seconds.
3. Remove spark plug and check for fuel at tip.
 - a. If there is fuel at tip of spark plug fuel pump and injector are operating.
 - b. If there is no fuel at tip of spark plug, check following:
 1. Make sure fuel tank contains clean, fresh, proper fuel.
 2. Make sure that vent in fuel tank is open.
 3. Make sure fuel tank valve (if equipped) is fully opened.
 4. Make sure battery is supplying proper voltage.
 5. Check that fuses and fuel pump relay are good, and that no electrical or fuel line connections are damaged or broken.
 6. Test fuel pump operation as described in original equipment manufacturer's manual.

Fault Codes

Example of Diagnostic Display

| | | |
|-------------------------|---|-----------------|
| ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ (0) | } | Fault Code 0107 |
| One second pause | | |
| ★ (1) | | |
| One second pause | } | |
| ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ (0) | | |
| One second pause | | |
| ★ ★ ★ ★ ★ ★ ★ ★ (7) | } | |
| Three second pause | | |
| ★ ★ ★ ★ ★ ★ ★ ★ (6) | | |
| One second pause | } | End Code 61 |
| ★ (1) | | |

Diagnostic Fault Code Summary

| Fault Code | Connection or Failure Description |
|-------------------|---|
| 0031 | Oxygen Sensor Heater Circuit Low Voltage |
| 0032 | Oxygen Sensor Heater Circuit High Voltage |
| 0107 | Manifold Absolute Pressure (TMAP) Circuit Low Voltage or Open |
| 0108 | Manifold Absolute Pressure (TMAP) Circuit High Voltage |
| 0112 | Intake Air Temperature (TMAP) Circuit Low Voltage |
| 0113 | Intake Air Temperature (TMAP) Circuit High Voltage or Open |
| 0117 | Engine Temperature Sensor Circuit Low Voltage |
| 0118 | Engine Temperature Sensor Circuit High Voltage or Open |
| 0122 | Throttle Position Sensor Circuit Low Voltage or Open |
| 0123 | Throttle Position Sensor Circuit High Voltage |
| 0131 | Oxygen Sensor 1 Circuit Low Voltage, or Open |
| 0132 | Oxygen Sensor 1 Circuit High Voltage |
| 0171 | Maximum Adaptation Limit Exceeded |
| 0172 | Minimum Adaptation Limit Exceeded |
| 0174 | Lean Fuel Condition at High Load (Open Loop) |
| 0201 | Injector Circuit Malfunction |
| 0230 | Fuel Pump Relay Circuit Low Voltage or Open |
| 0232 | Fuel Pump Relay Circuit High Voltage |
| 0336 | Crankshaft Position Sensor Noisy Signal |
| 0337 | Crankshaft Position Sensor No Signal |
| 0351 | Ignition Coil Malfunction |
| 0562 | System Voltage Low |
| 0563 | System Voltage High |
| 0650 | MIL Circuit Malfunction |
| 61 | End of Code Transmission |

MIL Operation for Pedal Start Applications

Key ON/MIL on for 3 seconds then turns off. MIL will remain off during normal operation or until a trouble code/fault is detected or until key switch is cycled power OFF for 15 seconds and returned to key ON position.

If code/fault is detected and is a current code, light will remain on for duration of operating cycle (key ON). If code/fault is temporarily detected and fault is recorded and then returns to normal, MIL will go out, but code is stored in ECU as a historic code.

MIL Operation for Key Start Applications

ECU continuously monitors engine operation against preset performance limits. If operation is outside limits, ECU activates MIL, if equipped, and stores a diagnostic code in its fault memory. If component or system returns to proper function, ECU will turn off MIL. If MIL stays illuminated, it warns customer a fault is currently happening, and dealer service is required. Upon receipt, dealer technician can access fault code(s) to help determine what portion of system is malfunctioning.

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

1. Check that battery voltage is above 11 volts.
2. Start with key switch OFF.
3. Turn key switch to ON and OFF, then ON and OFF, then ON, leaving it on in third sequence. Do not start engine. Time between sequences must be less than 2.5 seconds.

4. MIL will blink a series of times. Number of times MIL blinks represents a number in fault code.
5. A sequence of four digits make up a fault code. There is a one (1) second pause between blinks of a fault code. There is a three (3) second pause between separate fault codes. After fault code(s) are blinked a two digit 61 is blinked to indicate program has completed. Zero (0) = ten (10) blinks.
 - a. It's a good idea to write down codes as they appear, as they may not be in numerical sequence.
 - b. Code 61 will always be last code displayed, indicating end of code transmission. If code 61 appears immediately, no other fault codes are present.

After problem has been corrected, fault codes may be cleared by following ECU Reset and TPS Learn Procedures.

Diagnostic Fault Code Summary lists fault codes, and what they correspond to. Diagnostic Code Summary is a list of individual codes with an explanation of what triggers them, what symptoms might be expected, and probable causes.

EFI SYSTEM

Diagnostic Code Summary

Code 0031

NOTE: Codes 0031 and 0032 may have been mistakenly activated by turning key ON with oxygen sensor disconnected. If either code status is historic, that code may have set during assembly or a previous repair and may not be related to current event. Clear codes and retest to confirm. If code status is current, refer to Oxygen Sensor (O2) earlier in this section, to test and troubleshoot.

| | |
|-------------|--|
| Component: | Oxygen Sensor Heater |
| Fault: | O2S Heater Circuit Low Voltage |
| Condition: | System voltage too low, open connection or faulty sensor. |
| Conclusion: | <p>Engine Wiring Harness Related</p> <ul style="list-style-type: none"> Pin circuit wiring or connectors. ECU black pin 7 or broken wire. <p>Oxygen Sensor Related</p> <ul style="list-style-type: none"> Sensor connector or wiring problem. <p>Poor system ground from ECU to engine or battery to engine.</p> |

Code 0032

NOTE: Codes 0031 and 0032 may have been mistakenly activated by turning key ON with oxygen sensor disconnected. If either code status is historic, that code may have set during assembly or a previous repair and may not be related to current event. Clear codes and retest to confirm. If code status is current, refer to Oxygen Sensor (O2) earlier in this section, to test and troubleshoot.

| | |
|-------------|---|
| Component: | Oxygen Sensor Heater |
| Fault: | O2S Heater Circuit High Voltage |
| Condition: | System voltage too high, shorted connection or faulty sensor. |
| Conclusion: | <p>Oxygen Sensor Related</p> <ul style="list-style-type: none"> Sensor connector or wiring problem. Sensor damaged. Pin circuit wiring or connectors at Black 7. <p>ECU Related</p> <ul style="list-style-type: none"> ECU-to-harness connection problem. |

Code 0107

| | |
|-------------|---|
| Component: | Manifold Absolute Pressure (TMAP) |
| Fault: | MAP Circuit Low Voltage or Open |
| Condition: | Throttle body leak, open connection or faulty sensor. |
| Conclusion: | <p>TMAP Sensor Related</p> <ul style="list-style-type: none"> Sensor malfunction. Vacuum leaks from loose throttle body or sensor. <p>Wire Harness Related</p> <ul style="list-style-type: none"> Poor grounding or open circuit. Wire harness and connectors loose, damaged or corroded. Pin circuit wiring or connectors at Black 10, 11 and 16. <p>Bad TPS Learn.</p> |

Code 0108

| | |
|-------------|---|
| Component: | Manifold Absolute Pressure (TMAP) |
| Fault: | MAP Circuit High Voltage |
| Condition: | Throttle body leak, shorted connection or faulty sensor. |
| Conclusion: | <p>TMAP Sensor Related</p> <ul style="list-style-type: none"> Sensor malfunction. Vacuum leaks from loose throttle body or sensor. <p>Wire Harness Related</p> <ul style="list-style-type: none"> Poor grounding. Pin circuit wiring or connectors at Black 11. <p>Bad TPS Learn.</p> |

Code 0112

| | |
|-------------|---|
| Component: | Intake Air Temperature (TMAP) |
| Fault: | Intake Air Temperature Sensor Circuit Low Voltage |
| Condition: | Shorted connection, faulty sensor or shorted wire. |
| Conclusion: | <p>TMAP Sensor Related</p> <ul style="list-style-type: none"> • Sensor wiring or connection. <p>Engine Wiring Harness Related</p> <ul style="list-style-type: none"> • Pin circuits Black 10 and Black 8 may be damaged or routed near noisy signal (coil, alternator, etc.). • ECU-to-harness connection problem. |

Code 0113

| | |
|-------------|--|
| Component: | Intake Air Temperature (TMAP) |
| Fault: | Intake Air Temperature Sensor Circuit High Voltage or Open |
| Condition: | Shorted connection, faulty sensor, broken wire or connection. |
| Conclusion: | <p>TMAP Related</p> <ul style="list-style-type: none"> • Sensor wiring or connection. <p>Engine Wiring Harness Related</p> <ul style="list-style-type: none"> • Pin circuits ECU Black pin 10 and 8 may be damaged. • ECU-to-harness connection problem or broken wire. |

Code 0117

| | |
|-------------|---|
| Component: | Engine Temperature Sensor |
| Fault: | Engine Temperature Sensor Circuit Low Voltage |
| Condition: | Shorted connection, faulty sensor or shorted wire. |
| Conclusion: | <p>Temperature Sensor Related</p> <ul style="list-style-type: none"> • Sensor wiring or connection. <p>Engine Wiring Harness Related</p> <ul style="list-style-type: none"> • Pin circuits Black 10 and Black 14 maybe damaged or routed near noisy signal (coils, stator, etc.). • ECU-to-harness connection problem. |

Code 0118

| | |
|-------------|---|
| Component: | Engine Temperature Sensor |
| Fault: | Engine Temperature Sensor Circuit High Voltage or Open |
| Condition: | Shorted connection, faulty sensor, open connection or broken wire. |
| Conclusion: | <p>Temperature Sensor Related</p> <ul style="list-style-type: none"> • Sensor wiring or connection. <p>Engine Wiring Harness Related</p> <ul style="list-style-type: none"> • Pin circuits ECU Black pin 10 and 14 may be damaged. • ECU-to-harness connection problem or broken wire. <p>System Related</p> <ul style="list-style-type: none"> • Engine is operating above 176°C (350°F) temperature sensor limit. |

EFI SYSTEM

Code 0122

| | |
|-------------|---|
| Component: | Throttle Position Sensor (TPS) |
| Fault: | TPS Circuit Low Voltage or Open |
| Condition: | Open connection, broken wire or faulty sensor. |
| Conclusion: | <p>TPS Related</p> <ul style="list-style-type: none"> • TPS bad or worn internally. <p>Engine Wiring Harness Related</p> <ul style="list-style-type: none"> • Broken or shorted wire in harness. ECU Black pin 10 to TPS pin B. ECU Black pin 12 to TPS pin A. ECU Black pin 16 to TPS pin C. <p>Throttle Body Related</p> <ul style="list-style-type: none"> • Throttle shaft inside TPS worn, broken, or damaged. • Throttle plate loose or misaligned. • Throttle plate bent or damaged allowing extra airflow past, or restricting movement. <p>ECU Related</p> <ul style="list-style-type: none"> • Circuit providing voltage or ground to TPS damaged. • TPS signal input circuit damaged. |

Code 0123

| | |
|-------------|---|
| Component: | Throttle Position Sensor (TPS) |
| Fault: | TPS Circuit High Voltage |
| Condition: | Shorted connection or faulty sensor. |
| Conclusion: | <p>TPS Sensor Related</p> <ul style="list-style-type: none"> • Sensor connector or wiring. • Sensor output affected or disrupted by dirt, grease, oil, wear. • Sensor loose on throttle body. <p>Throttle Body Related</p> <ul style="list-style-type: none"> • Throttle shaft or bearings worn/damaged. <p>Engine Wiring Harness Related</p> <ul style="list-style-type: none"> • ECU pins Black 10, 12 and 16 damaged (wiring, connectors). • ECU pins Black 10, 12 and 16 routed near noisy electrical signal (coil, alternator). • Intermittent 5 volt source from ECU (pin Black 16). • ECU-to-harness connection problem. |

Code 0131

| | |
|-------------|---|
| Component: | Oxygen Sensor |
| Fault: | O2S 1 Circuit Low Voltage |
| Condition: | Open connection, broken wire or faulty sensor. |
| Conclusion: | <p>Oxygen Sensor Related</p> <ul style="list-style-type: none"> • Sensor connector or wiring problem. • Sensor contaminated, corroded or damaged. • Poor ground path. • Pin circuit wiring or connectors. ECU Black pin 10 or 17. <p>TPS Learn Procedure Incorrect</p> <ul style="list-style-type: none"> • Lean condition (check oxygen sensor signal with VOA and refer to Oxygen Sensor section). <p>Engine wiring harness related such as a cut wire, broken or pinched.</p> |

Code 0132

| | |
|-------------|--|
| Component: | Oxygen Sensor |
| Fault: | O2S 1 Circuit High Voltage |
| Condition: | Shorted connection or faulty sensor. |
| Conclusion: | <p>Oxygen Sensor Related</p> <ul style="list-style-type: none"> • Sensor connector or wiring problem. • Sensor contaminated or damaged. • Poor ground path. • Pin circuit wiring or connectors. ECU Black pin 10 or Black pin 17. <p>Engine Wiring Harness Related</p> <ul style="list-style-type: none"> • Difference in voltage between sensed voltage and actual sensor voltage. • Short in wire harness. |

Code 0171

| | |
|-------------|--|
| Component: | Fuel System |
| Fault: | Maximum adaptation limit exceeded |
| Condition: | Fuel inlet screen/filter plugged, low pressure at high pressure fuel line, TPS malfunction, shorted connection, faulty sensor, low fuel or wrong fuel type. |
| Conclusion: | <p>Oxygen Sensor Related</p> <ul style="list-style-type: none"> • Corrosion or poor connection. • Sensor contaminated or damaged. • Air leak into exhaust. • Poor ground path. • Pin circuit wiring or connectors. <p>ECU Black pin 10 or Black pin 17.</p> <p>TPS Sensor Related</p> <ul style="list-style-type: none"> • Throttle plate position incorrect during Learn procedure. • TPS problem or malfunction. <p>Engine Wiring Harness Related</p> <ul style="list-style-type: none"> • Difference in voltage between sensed voltage and actual sensor voltage. • Problem in wiring harness. • ECU-to-harness connection problem. <p>Systems Related</p> <ul style="list-style-type: none"> • Ignition (spark plug, plug wire, ignition coil). • Fuel (fuel type/quality, injector, fuel pressure too low, fuel pump). • Combustion air (air cleaner dirty/restricted, intake leak, throttle bore). • Base engine problem (rings, valves). • Exhaust system leak (muffler, flange, oxygen sensor mounting boss, etc.). • Fuel in crankcase oil. |

Code 0172

| | |
|-------------|--|
| Component: | Fuel System |
| Fault: | Minimum adaptation limit exceeded |
| Condition: | Too high pressure at high pressure fuel line, TPS malfunction, shorted connection, faulty sensor or fuel pump failure. |
| Conclusion: | <p>Oxygen Sensor Related</p> <ul style="list-style-type: none"> • Sensor connector or wiring. • Sensor contaminated or damaged. • Poor ground path. • Pin circuit wiring or connectors. <p>ECU Black pin 10 or 17.</p> <p>TPS Sensor Related</p> <ul style="list-style-type: none"> • Throttle plate position incorrect during Learn procedure. • TPS problem or malfunction. <p>Engine Wiring Harness Related</p> <ul style="list-style-type: none"> • Difference in voltage between sensed voltage and actual sensor voltage. • Problem in wiring harness. • ECU-to-harness connection problem. <p>Systems Related</p> <ul style="list-style-type: none"> • Ignition (spark plug, plug wire, ignition coil). • Fuel (fuel type/quality, injector, fuel pressure too high, fuel pump). • Combustion air (air cleaner dirty/restricted). • Base engine problem (rings, valves). • Fuel in crankcase oil. |

EFI SYSTEM

Code 0174

| | |
|-------------|--|
| Component: | Fuel System |
| Fault: | Lean fuel condition |
| Condition: | Fuel inlet screen/filter plugged, low pressure at high pressure fuel line, TPS malfunction, shorted connection or faulty sensor. |
| Conclusion: | <p>TPS Learn Incorrect</p> <ul style="list-style-type: none"> Lean condition (check oxygen sensor signal with VOA and refer to Oxygen Sensor). <p>Engine Wiring Harness Related</p> <ul style="list-style-type: none"> Pin circuit wiring or connectors. ECU pin Black 10, 12, 16 and 17. <p>Low Fuel Pressure</p> <ul style="list-style-type: none"> Plugged filters. <p>Oxygen Sensor Related</p> <ul style="list-style-type: none"> Sensor connector or wiring problem. Exhaust leak. Poor ground. <p>Poor system ground from ECU to engine, causing rich running while indicating lean.</p> <p>Fuel pump connection. Refer to equipment manufacturer's manual for information.</p> |

Code 0201

| | |
|-------------|---|
| Component: | Fuel Injector |
| Fault: | Injector Circuit Malfunction |
| Condition: | Injector damaged or faulty, shorted or open connection. |
| Conclusion: | <p>Injector Related</p> <ul style="list-style-type: none"> Injector coil shorted or opened. <p>Engine Wiring Harness Related</p> <ul style="list-style-type: none"> Broken or shorted wire in harness. ECU pin Black 5. Wiring from Ignition. <p>ECU Related</p> <ul style="list-style-type: none"> Circuit controlling injector damaged. |

Code 0230

| | |
|-------------|---|
| Component: | Fuel Pump Relay |
| Fault: | Circuit Low Voltage or Open |
| Condition: | Shorted or open connection. |
| Conclusion: | <p>Fuel Pump Relay Related</p> <ul style="list-style-type: none"> Fuel pump relay open or shorted internally. <p>Engine Wiring Harness related</p> <ul style="list-style-type: none"> Broken or shorted wire in harness. ECU pin Black 9 or Grey 17. <p>ECU Related</p> <ul style="list-style-type: none"> ECU is damaged. |

Code 0232

| | |
|-------------|--|
| Component: | Fuel Pump Relay |
| Fault: | Circuit High Voltage |
| Condition: | Shorted connection. |
| Conclusion: | <p>Fuel Pump Relay Related</p> <ul style="list-style-type: none"> Fuel pump damaged internally. <p>Charging Output System Too High.</p> |

Code 0336

| | |
|-------------|--|
| Component: | Crankshaft Position Sensor |
| Fault: | Crankshaft Position Sensor Noisy Signal |
| Condition: | Loose sensor, faulty/bad battery, shorted or faulty connection, faulty sensor or faulty sensor grounding. |
| Conclusion: | <p>Crankshaft Position Sensor Related</p> <ul style="list-style-type: none"> • Sensor connector or wiring. • Sensor loose. <p>Crankshaft Position Sensor Wheel Related</p> <ul style="list-style-type: none"> • Damaged teeth. • Gap section not registering. <p>Engine Wiring Harness Related</p> <ul style="list-style-type: none"> • Pin circuit wiring or connectors. ECU pin Black 4 and Black 13. • ECU-to-harness connection problem. <p>Ignition System Related</p> <ul style="list-style-type: none"> • Non-resistor spark plug used. • Faulty or disconnected ignition coil or secondary lead. |

Code 0337

NOTE: If fault code P0337 is present and engine does not start/run, proceed to step 1 of Crankshaft Position Sensor earlier in this section. If P0337 is present and engine operates, clear codes and retest.

| | |
|-------------|---|
| Component: | Crankshaft Position Sensor |
| Fault: | Crankshaft Position Sensor No Signal |
| Condition: | Loose sensor, open or shorted connection (sensor connector or battery connections) or faulty sensor. |
| Conclusion: | <p>Crankshaft Position Sensor Related</p> <ul style="list-style-type: none"> • A false fault code P0337 is triggered by a voltage drop with key ON and engine off. Voltage drop may be caused by a poor/inadequate battery connection, battery charger connected or disconnected, or any event that may interrupt voltage signal to ECU like a power interruption or heavy load from equipment that results in a recordable voltage drop. • Sensor connector or wiring. • Sensor loose. <p>Crankshaft Position Sensor Wheel Related</p> <ul style="list-style-type: none"> • Damaged teeth. <p>Engine Wiring Harness Related</p> <ul style="list-style-type: none"> • Pin circuit wiring or connectors. ECU pin Black 4 or Black 13. • ECU-to-harness connection problem. <p>If code is stored in fault history and starts normally. Clear code, no other service required.</p> |

EFI SYSTEM

Code 0351

| | |
|-------------|---|
| Component: | Ignition Coil |
| Fault: | Ignition Coil Malfunction |
| Condition: | Broken wire in harness (may not be visible), shorted connection or faulty sensor. |
| Conclusion: | Engine Wiring Harness Related <ul style="list-style-type: none"> • Connection to ignition or fuse. • Pin circuit wiring or connectors. • ECU pin Black 1. • ECU-to-harness connection problem. Ignition System Related <ul style="list-style-type: none"> • Incorrect spark plug used. • Poor connection to spark plug. |

Code 0562

| | |
|-------------|---|
| Component: | System Voltage |
| Fault: | System Voltage Low |
| Condition: | Bad fuse or shorted connection. |
| Conclusion: | Corroded Connections Bad Battery* <ul style="list-style-type: none"> • Low output charging system.* • Bad or missing fuse.* *Refer to equipment manufacturer's manual for information. |

Code 0563

| | |
|-------------|---|
| Component: | System Voltage |
| Fault: | System Voltage High |
| Condition: | Shorted connection. |
| Conclusion: | Bad Battery.* <ul style="list-style-type: none"> • Low output charging system.* *Refer to equipment manufacturer's manual for information. |

Code 0650

| | |
|-------------|---|
| Component: | MIL Circuit |
| Fault: | MIL Circuit Malfunction |
| Condition: | Failure in MIL circuit detected. |
| Conclusion: | Bad Connection. Broken Wire. Bad ECU. |

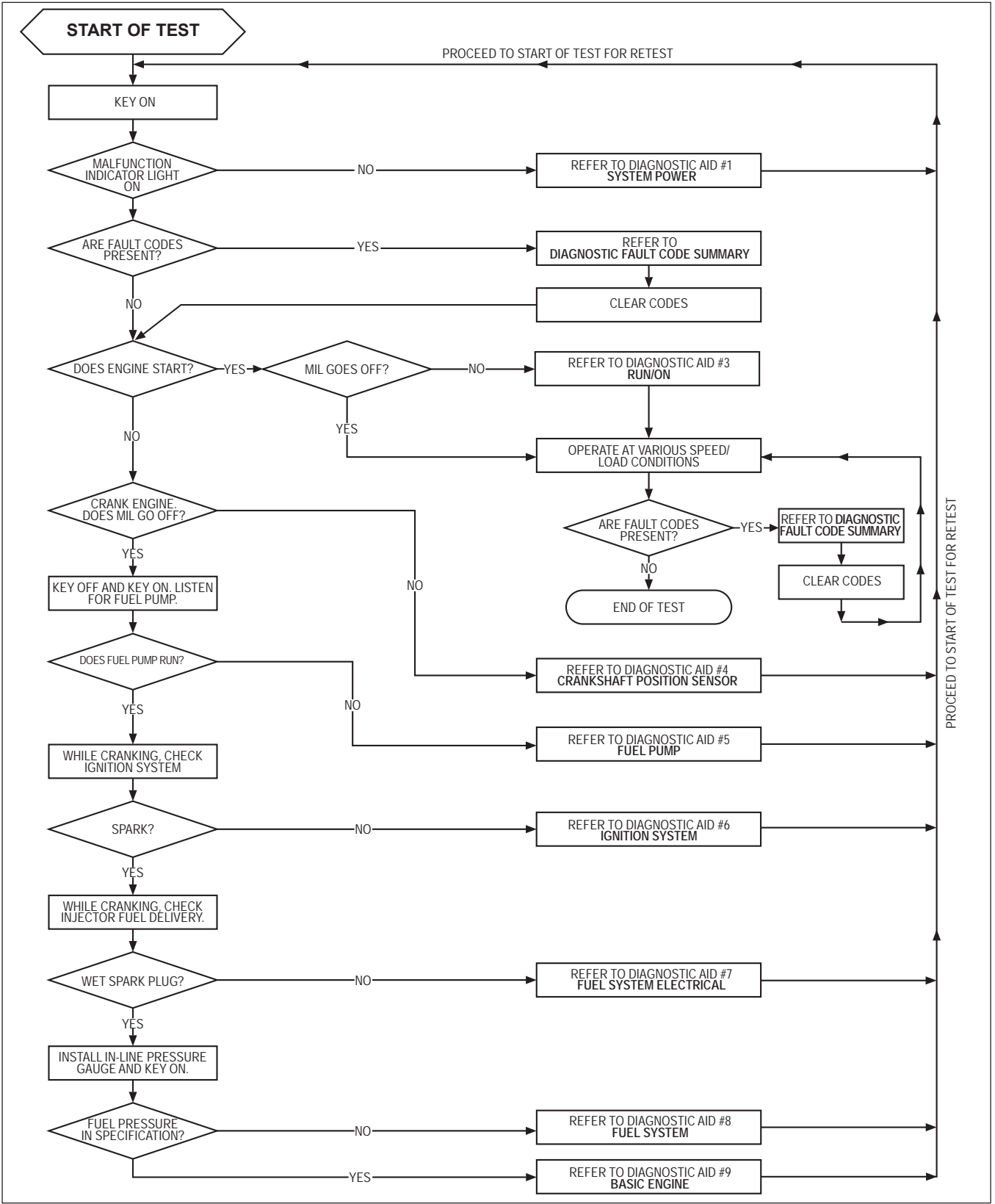
Code 61

| | |
|------------|--------------------------|
| Component: | End of Code Transmission |
|------------|--------------------------|

Troubleshooting Flow Chart

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

EFI Diagnostic Flow Diagram



EFI SYSTEM

Flow Chart Diagnostic Aids

Diagnostic Aid #1 SYSTEM POWER

(MIL does not illuminate for 3 seconds when key is first turned ON)

NOTE: MIL is installed by vehicle OEM. Twelve volt supply to bulb will be part of vehicle wire harness. Review **MIL Operation for Pedal Start Applications** or **MIL Operation for Key Start Applications** earlier in this section.

Conclusion

- Battery
- Main system fuse
- MIL light bulb burned out
- MIL electrical circuit problem
Pin circuits Grey 3.
- Ignition switch
- Permanent ECU power circuit problem
Pin circuit Black 18.
- Switched ECU power circuit problem
Pin circuit Black 15.
- ECU grounds
- ECU

Diagnostic Aid #2 FAULT CODES

Refer to Diagnostic Fault Code Summary.

NOTE: If fault code P0337 is present and engine does not start/run, proceed to step 1 of Crankshaft Position Sensor earlier in this section. If P0337 is present and engine operates, clear codes and retest.

Diagnostic Aid #3 RUN/ON

(MIL remains ON while engine is running)

Conclusion

- All current fault codes will turn on MIL when key is ON or engine is running.
- If MIL is on and no fault codes are active, check MIL wiring between ECU and bulb.

Diagnostic Aid #4 CRANKSHAFT POSITION SENSOR

(MIL does not turn off during cranking)

Condition

- Crankshaft position sensor
- Crankshaft position sensor circuit problem, pin circuits Black 4 and Black 13.
- Crankshaft position sensor/toothed wheel air gap
- Toothed wheel
- Flywheel key sheared
- ECU

Diagnostic Aid #5 FUEL PUMP

(fuel pump not turning on)

Condition

- Inspect fuse(s)
- Fuel pump relay circuit problem, pin circuits Black 9 and Grey 17.
- Fuel pump

Diagnostic Aid #6 IGNITION SYSTEM

(no spark)

Condition

- Spark plug
- Plug wire
- Coil
- Coil circuit, pin circuits Grey 10 and Black 1.
- ECU grounds
- ECU
- Vehicle safety interlocks, refer to equipment manufacturer's manual

Diagnostic Aid #7 FUEL SYSTEM ELECTRICAL

(no fuel delivery)

Condition

- No fuel
- Air in high pressure fuel line
- Fuel filter/line plugged
- Injector circuit, pin circuits Black 5 and Black 6
- Injector
- ECU grounds
- ECU

Diagnostic Aid #8 FUEL SYSTEM

(fuel pressure)

Low Fuel Pressure-Condition

- No fuel
- Fuel filter(s) plugged
- Fuel supply line plugged
- Fuel pump - internally plugged
- Pressure regulator not functioning properly inside fuel pump.

Diagnostic Aid #9 BASIC ENGINE

(cranks but will not run)

Condition

- Refer to basic engine troubleshooting charts within Troubleshooting and/or refer to equipment manufacturer's manual.

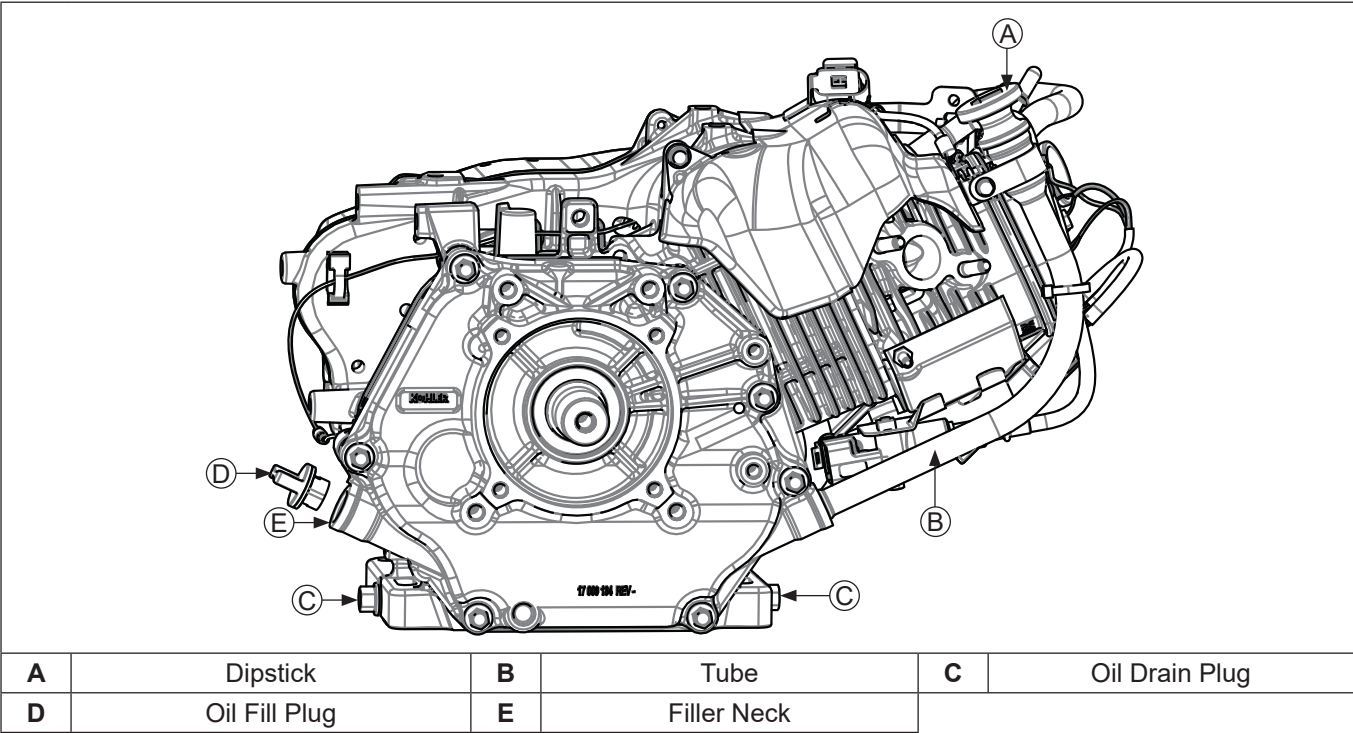
GOVERNOR (OEM Supplied)

Refer to operating instructions of equipment this engine powers for specific governor instructions.

Lubrication System

These engines use a splash lubrication system, supplying necessary lubrication to crankshaft, camshaft, connecting rod and valve train components.

Lubrication Components



WINTER LUBRICATION

If engine is frequently used for short periods of time in ambient temperatures below 4°C (40°F), reduce oil change intervals to every 25 hours.

A rise in oil level during cold weather operation can indicate contaminants collecting in crankcase. If oil level begins to rise:

1. Run vehicle longer to bring engine up to operating temperature before shutting it off. Continuous running for a period of 30 minutes will stabilize engine temperatures.
2. Change oil if oil level begins to rise over full mark on dipstick.
3. Monitor oil level and if it continues to rise, discontinue use and contact your dealer.

NOTE: As ambient weather temperatures decrease below 4°C (40°F), more frequent oil changes may be required. Water vapor is a normal by-product of combustion in any engine. During cold weather operation, some water vapor condenses into liquid form on cool metal surfaces inside engine. In cold weather, this water will accumulate and become mixed with engine oil. In addition to water vapor in cold conditions, liquid fuel can pass by piston rings and accumulate in engine oil. Emulsified fluids in oil can give the oil a cloudy or milky appearance. If engine is run at normal operating temperatures, most of this water and fuel will become vapor and will be passed through breather.

OIL RECOMMENDATIONS

Refer to Maintenance.

CHECK OIL LEVEL

NOTE: To prevent extensive engine wear or damage, never run engine with oil level below or above operating range indicator on dipstick.

Ensure engine is cool and level. Clean oil fill/dipstick areas of any debris.

1. Check oil level using dipstick or oil fill plug.
 - a. Push-on cap dipstick: Remove dipstick; wipe oil off. Reinsert dipstick into tube; press down completely. Remove dipstick; check oil level. Level should be at top of indicator on dipstick.
 - or
 - b. Remove oil fill plug. Level should be up to point of overflowing filler neck.
2. If oil is low, add oil up to top of indicator mark on dipstick or to point of overflowing filler neck.
3. Reinstall and secure dipstick or oil fill plug.

CHANGE OIL

Change oil while engine is warm.

1. Clean area around oil fill plug/dipstick and drain plug.
2. Remove drain plug and oil fill plug/dipstick. Drain oil completely.
3. Reinstall drain plug. Torque to 18 N·m (13 ft. lb.).

4. Fill crankcase with new oil, up to point of overflowing filler neck.
5. Reinstall oil fill plug/dipstick and tighten securely.
6. Dispose of used oil in accordance with local ordinances.

OIL SENTRY™ (if equipped)

This switch is designed to prevent engine from starting in a low oil or no oil condition. Oil Sentry™ may not shut down a running engine before damage occurs. In some applications this switch may activate a warning signal. Read your equipment manuals for more information.

Oil Sentry™ Oil Level Sensor Switch Testing (if equipped)

Some engines are equipped with an oil level sensor switch. This switch is connected to equipment through 8-pin customer connector. It provides a switching mechanism using continuity to indicate a safe operating oil level.

No continuity from switch indicates a safe (full) operating oil level.

Continuity from switch indicates a unsafe (low) operating oil level.

Review these troubleshooting guidelines.

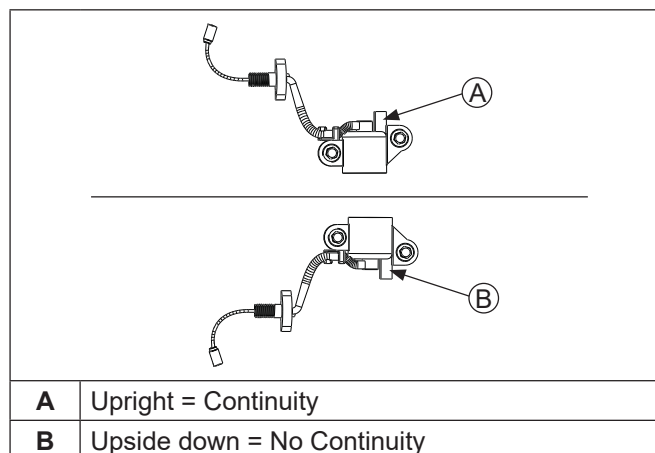
1. Set an ohmmeter to Rx1 scale and zero meter. Connect one ohmmeter lead to Oil Sentry™ oil level switch lead (yellow with green sleeve) and touch other lead to a bare spot on crankcase (ground). Drain oil from crankcase and repeat test.

With oil at proper level, no continuity should have been indicated. After oil was drained, continuity should have been indicated.

| Condition | Conclusion |
|--------------------------|---|
| No continuity indicated. | Remove closure plate from engine and remove oil level switch for further testing (steps 1a and 1b). |

- a. If continuity was indicated with and without oil above, check if insulation has been scraped off oil level switch lead.

| Condition | Conclusion |
|--------------------|--|
| Lead wire is bare. | Allowing it to short, repair with electrical tape or replace oil level switch. |




- b. With oil level switch removed, connect one ohmmeter lead to oil level switch lead terminal and connect other lead to mounting bracket. Test resistance with switch in normal position and inverted. Repeat test 2 or 3 times in each direction.

| Condition | Conclusion |
|---|---------------------|
| Switch continuity should be as indicated. | If not, replace it. |

Electrical System

BATTERY CHARGING SYSTEM (OEM Supplied)

| | |
|--|---|
|  | CAUTION |
| | Electrical Shock can cause injury. Do not touch wires while engine is running. |

Engines in this application have an original equipment manufacturer (OEM) supplied starter generator. Refer to OEM manual for starter generator charging system troubleshooting information.

Battery

A 12-volt battery with 400 cold cranking amps (cca) is generally recommended for starting in all conditions. A smaller capacity battery is often sufficient if an application is started only in warmer temperatures. Refer to following table for minimum capacities based on anticipated ambient temperatures. Actual cold cranking requirement depends on engine size, application, and starting temperatures. Cranking requirements increase as temperatures decrease and battery capacity shrinks. Refer to operating instructions of equipment for specific battery requirements.

Battery Size Recommendations

| Temperature | Battery Required |
|------------------------------|------------------|
| Above 32°F (0°C) | 300 cca minimum |
| 0°F to 32°F (-18°C to 0°C) | 300 cca minimum |
| -5°F to 0°F (-21°C to -18°C) | 300 cca minimum |
| -10°F (-23°C) or below | 400 cca minimum |

If battery charge is insufficient to turn over engine, recharge battery.

Battery Maintenance

Regular maintenance is necessary to prolong battery life.

Battery Test

To test battery, follow manufacturer's instructions.

FUSES

This engine has 2 blade type automotive fuses. Replacement fuses must have same rating as blown fuse. Use fuse chart below to determine correct fuse.

| Wire Color | Fuse Rating |
|--|-------------|
| 1 Red Wire w/Black Stripe 1 Red Wire w/White Stripe | 10-amp Fuse |
| 2 Red Wires | 10-amp Fuse |

Fuse Replacement

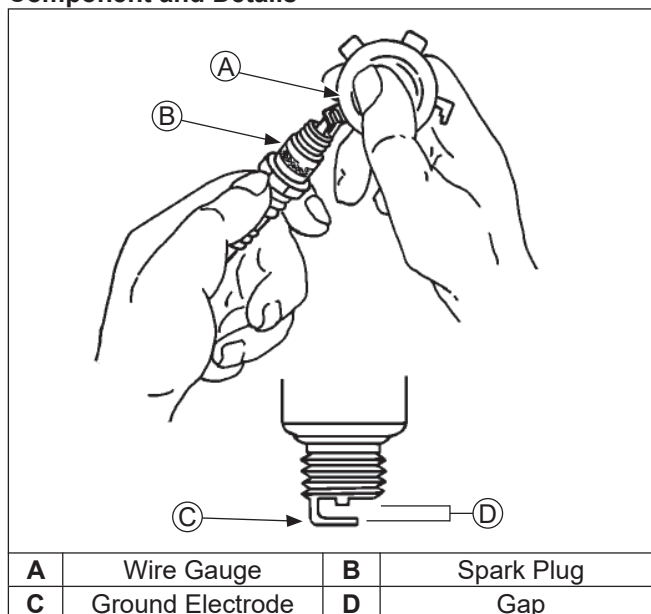
1. Shut engine off and remove key.
2. Locate fuse holders.
3. Remove fuse cover and pull out fuse holder. Inspect condition of fuse holder.
4. Inspect fuse for a solid fusible link or a broken fusible link. Replace fuse if fusible link is broken. If you are not sure if fusible link is broken, replace fuse.

5. Insert fuse into fuse holder until it is seated properly. Install fuse cover.
6. If replacement fuse fails, there is a problem within circuit. Diagnostics are required. Identify which circuit is affected (see EFI System for electrical schematic) by identifying failed fuse/circuit. Perform troubleshooting procedures appropriate for circuit fuse that failed.
7. Install fuse holder into fuse cover.

IGNITION SYSTEM

Spark Plug

Component and Details



NOTE: Do not clean spark plug in a machine using abrasive grit. Some grit could remain in spark plug and enter engine causing extensive wear and damage.

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

Engine is equipped with following spark plug:

| | |
|-------------|---------------------|
| Gap | 1.11 mm (0.044 in.) |
| Thread Size | 14 mm |
| Reach | 19.1 mm (3/4 in.) |
| Hex Size | 15.9 mm (5/8 in.) |

Refer to Maintenance for Repairs/Service Parts.

Service

Clean out spark plug recess. Remove plug and replace.

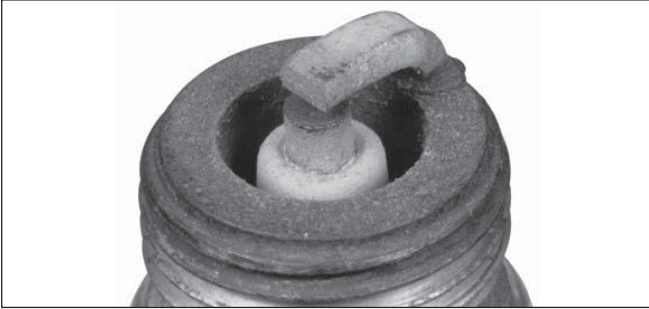
1. Check gap using wire feeler gauge. Adjust gap to 1.11 mm (0.044 in.).
2. Install plug into cylinder head.
3. Torque plug to 27 N·m (20 ft. lb.).

Inspection

Inspect spark plug as it is removed from cylinder head. Deposits on tip are an indication of general condition of piston rings, valves, and fuel mixture.

Normal and fouled plugs are shown in following photos:

Normal



Plug taken from an engine operating under normal conditions will have light tan or gray colored deposits. If center electrode is not worn, plug can be set to proper gap and reused.

Worn



On a worn plug, center electrode will be rounded and gap will be greater than specified gap. Replace a worn spark plug immediately.

Wet Fouled



A wet plug is caused by excess fuel or oil in combustion chamber. Excess fuel could be caused by a restricted air cleaner, a fuel mixture problem. Oil in combustion chamber is usually caused by a restricted air cleaner, a breather problem, worn piston rings, or valve guides.

Carbon Fouled



Soft, sooty, black deposits indicate incomplete combustion caused by a restricted air cleaner, over rich fuel mixture, weak ignition, or poor compression.

Overheated



Chalky, white deposits indicate very high combustion temperatures. This condition is usually accompanied by excessive gap erosion. Lean fuel mixture settings, an intake air leak, or incorrect spark timing are normal causes for high combustion temperatures.

Electrical System

Troubleshooting Guide

Test Ignition System

Isolate and verify trouble is within engine.

1. If Kohler diagnostic software is available, review "Safety System Active" status in Data Display screen. If yes is displayed, equipment safety circuit is active (Refer to equipment manufacturer's manual for safety system information). This must be corrected prior to continuing testing.

| Condition | Possible Cause | Conclusion |
|--------------------|-------------------------------|--|
| Problem goes away. | Electrical System | Check key switch, wires, connections, safety interlocks, etc. |
| Problem persists. | Ignition or Electrical System | Inspect wiring harness (primary and secondary) for any obvious issues. Testing of ignition coil is required. Refer to EFI System, Ignition Coil Testing for details. |

Test for Spark

NOTE: Do not crank engine or perform tests with spark plug lead disconnected and not grounded, or permanent coil damage may occur.




1. With engine stopped, disconnect spark plug lead. Connect spark plug lead to post terminal of spark tester and attach tester clip to a good engine ground.
2. Crank engine over, establishing a minimum of 550-600 RPM, and observe tester for spark.

| Condition | Possible Cause | Conclusion |
|---|--|---|
| Cylinder is not firing or has intermittent spark. | Wiring, Connections, or System Power | Using a DVOM, attach black (-) lead of meter to battery ground, remove primary plug from coil, test voltage at red wire with black tracer at coil primary connector with ignition key ON. Battery voltage should be seen. If no voltage, check all fuses. Key OFF, perform continuity test between black primary wire connector and corresponding pin terminal 1 on black ECU connector (refer to EFI System Wiring Diagram). If no continuity is found, repair or replace electrical wiring harness. If continuity is found, refer to EFI System, Ignition Coil Testing, test circuit (power and ground). Repair/replace as needed. Test ignition coil and connection. Refer to Test Ignition System (above). |
| Tester shows spark but engine misses or won't run. | Spark Plug | Try new spark plug. |
| | Flywheel Key | Remove flywheel, inspect key, replace key if damaged. |
| No spark. | Ignition Switch, EFI System, Kill Lead | Test for "Safety System Active" as described in step 1 of Test Ignition System (above). Inspect red 10 amp fuses. Replace fuse if found blown. If fuse is OK, using a DVOM, attach black (-) lead of meter to battery ground, key ON, test for voltage at 2 red 10 amp fuses. Battery voltage should be seen on both sides of fuses. If voltage is found on 1 side of fuse only, inspect for blown fuse or inspect fuse holder/terminals for arcing or corrosion. If no voltage is seen at any fuse, further electrical testing inspection is required (application, key switch, ground connections, etc.) Recheck position of ignition switch and check for shorted kill lead. |
| Good spark but engine runs poorly or existing plug condition is questionable. | Spark Plug | Install new spark plug and retest engine performance. |
| | Flywheel Key | Remove flywheel, inspect key, replace key if damaged. |

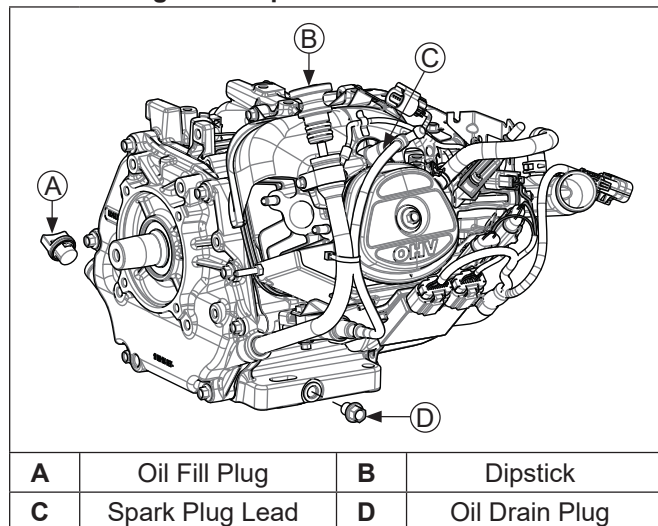
Starter (OEM Supplied)

Refer to operating instructions of equipment this engine powers for specific starter system instructions.

Disassembly/Inspection and Service

| | | |
|---|--|---|
|    | <p>⚠ WARNING</p> <p>Accidental Starts can cause severe injury or death.</p> <p>Disconnect and ground spark plug lead(s) before servicing.</p> | <p>Before working on engine or equipment, disable engine as follows: 1) Disconnect spark plug lead(s). 2) Disconnect negative (–) battery cable from battery.</p> |
|---|--|---|

External Engine Components



Clean all parts thoroughly as engine is disassembled. Only clean parts can be accurately inspected and gauged for wear or damage. There are many commercially available cleaners that will quickly remove grease, oil, and grime from engine parts. When such a cleaner is used, follow manufacturer's instructions and safety precautions carefully.

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

NOTE: Engines in this application have air cleaner, starter generator, in-tank fuel pump, EFI fuel filter, and all fuel lines supplied and installed by OEM. Refer to equipment manufacturer's manual for information on these components and before working on fuel system. Use only original equipment replacement parts.

Disconnect Spark Plug Lead

NOTE: Pull on boot only, to prevent damage to spark plug lead.

1. Disconnect lead from spark plug.
2. Turn off fuel at fuel supply.

Drain Oil From Crankcase

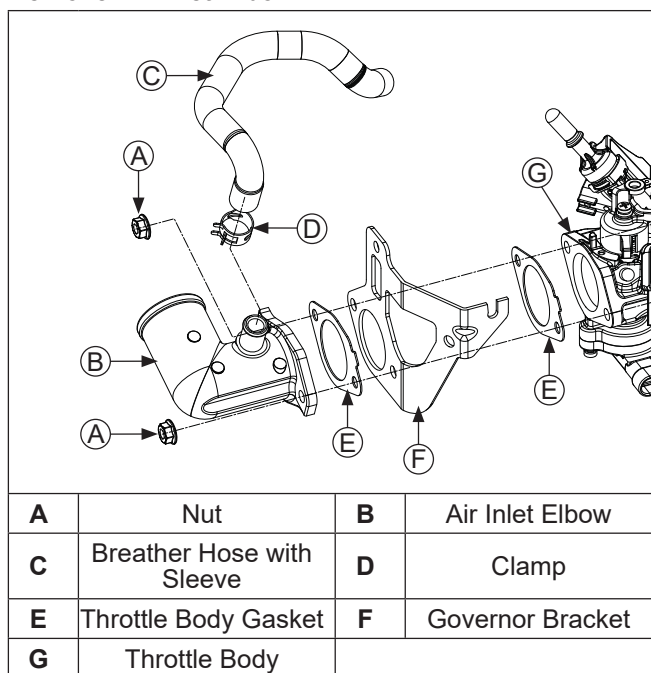
1. Remove 1 oil drain plug and oil fill plug or dipstick.
2. Allow ample time for oil to drain from crankcase.

Disconnect Oxygen Sensor

NOTE: Unless oxygen sensor is damaged or malfunctioning, disassembly from OEM supplied muffler is unnecessary.

Disconnect oxygen sensor connector from wire harness.

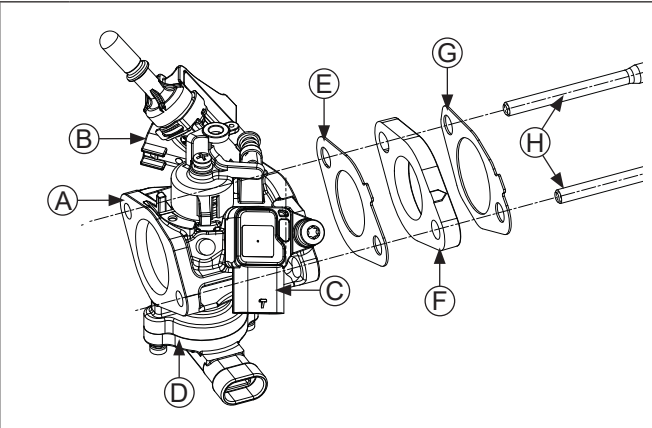
Remove Air Inlet Elbow



1. Remove nuts securing air inlet elbow.
2. Disconnect breather hose from valve cover.
3. Remove air inlet elbow and throttle body gasket from mounting studs.
4. Remove governor bracket and throttle body gasket from mounting studs.

Disassembly/Inspection and Service

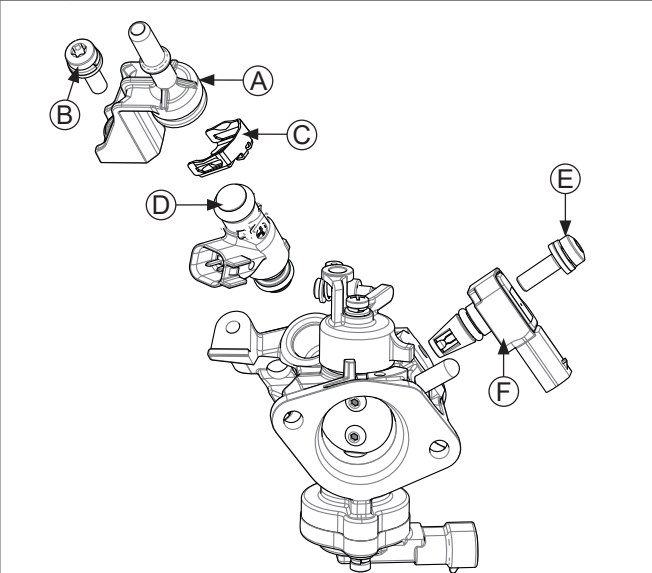
Remove Throttle Body Assembly



| | | | |
|---|-----------------------------------|---|--------------------------------|
| A | Throttle Body | B | Fuel Injector |
| C | TMAP | D | Throttle Position Sensor (TPS) |
| E | Insulator to Throttle Body Gasket | F | Insulator |
| G | Insulator to Cylinder Head Gasket | H | Intake Studs |

1. With a screwdriver, slide locking tab on electrical connector of TMAP. Detach connector.
2. Disconnect fuel injector electrical connector.
3. Disconnect throttle position sensor (TPS) connector.
4. Slide throttle body off intake studs and remove insulator to throttle body gasket, insulator, and insulator to cylinder head gasket.

Remove Fuel Injector and TMAP



| | | | |
|---|----------------------|---|---------------|
| A | Fuel Injector Cap | B | Screw |
| C | Metal Retaining Clip | D | Fuel Injector |
| E | Screw | F | TMAP |

Remove Fuel Injector

NOTE: Unless fuel injector is damaged or malfunctioning, disassembly from throttle body is unnecessary.

NOTE: Make note of fuel injector position before removing.

NOTE: Unless fuel injector cap is damaged, removing retainer securing cap to injector is unnecessary.

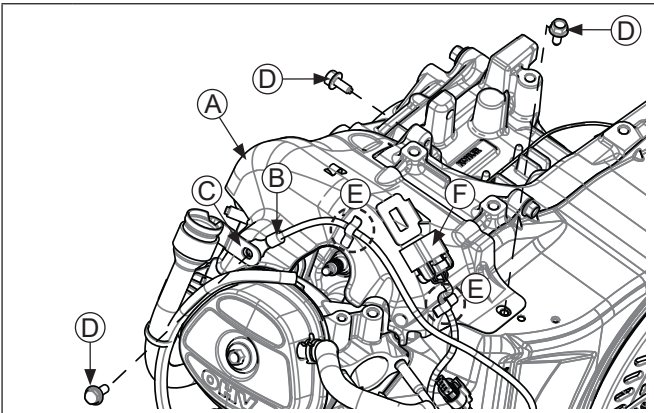
1. Disconnect fuel injector electrical connector.
2. Remove screw and pull injector out of throttle body.
3. When removed, pull metal retaining clip connecting fuel injector to fuel injector cap/fuel cap bracket. There may be some fuel left in line. Any spilled fuel must be cleaned up immediately.

Remove Temperature/Manifold Absolute Pressure (TMAP) Sensor

NOTE: Unless TMAP sensor is damaged or malfunctioning, disassembly from throttle body is unnecessary.

1. With a screwdriver, slide locking tab on electrical connector.
2. Detach connector.
3. Remove screw and pull TMAP sensor out of throttle body.

Remove Upper Heat Shield and Engine Temperature Sensor

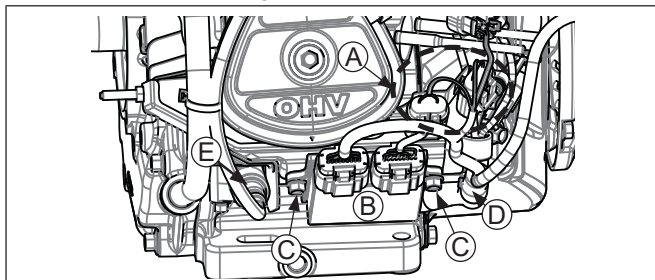


| | | | |
|---|-----------------------|---|---------------------------|
| A | Upper Heat Shield | B | Engine Temperature Sensor |
| C | Dipstick Tube Bracket | D | Screw |
| E | Clip | F | Oxygen Sensor Connector |

1. Note position of engine temperature sensor. Sensor is located between oil fill tube bracket and upper heat shield. Remove screw securing oil fill tube bracket and sensor to upper heat shield.
2. Remove engine temperature wire from upper heat shield clip. Remove oxygen sensor wire from upper heat shield clip.
3. Remove screws and lift off upper heat shield.

Disassembly/Inspection and Service

Fuses and ECU Components



| | | | |
|----------|--------------------|----------|------------|
| A | Fuses/Fuse Holders | B | ECU |
| C | Screw | D | Cable Clip |
| E | Ignition Coil | | |

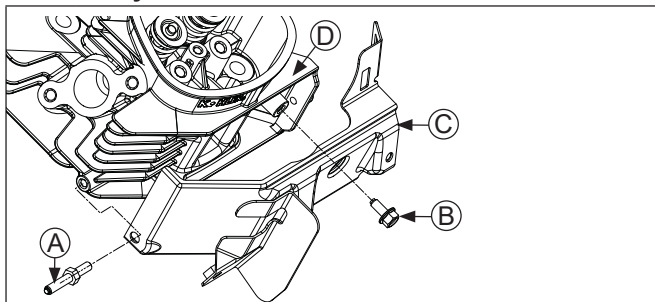
Remove Fuses

Remove fuses from holders located on lower shield.

Remove Electronic Control Unit (ECU)

1. Remove screws and remove ECU and cable clip with wiring harness from lower shield.
2. Disconnect Black and Grey electrical connectors from ECU.

Remove Cylinder Shield

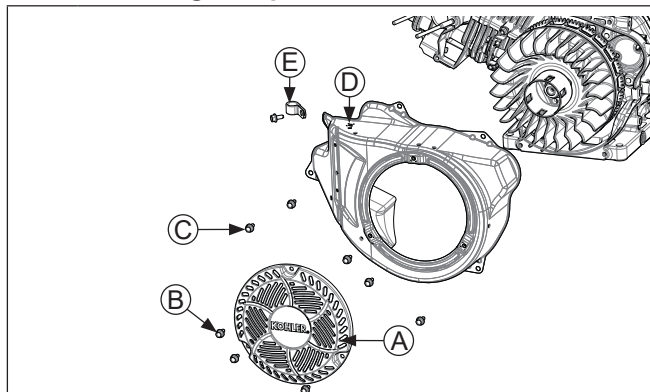


| | | | |
|----------|-----------------|----------|---------------|
| A | Ground Stud | B | Screw |
| C | Cylinder Shield | D | Cylinder Head |

NOTE: Unless ignition coil is damaged or malfunctioning, disassembly from lower shield is unnecessary.

1. Disconnect ignition coil electrical connector.
2. Remove screw and ground stud securing lower shield to cylinder head; remove lower shield.

Blower Housing Components



| | | | |
|----------|-----------------------|----------|----------------|
| A | Blower Housing Screen | B | Screw |
| C | Screw | D | Blower Housing |
| E | Clamp | | |

Remove Blower Housing Screen

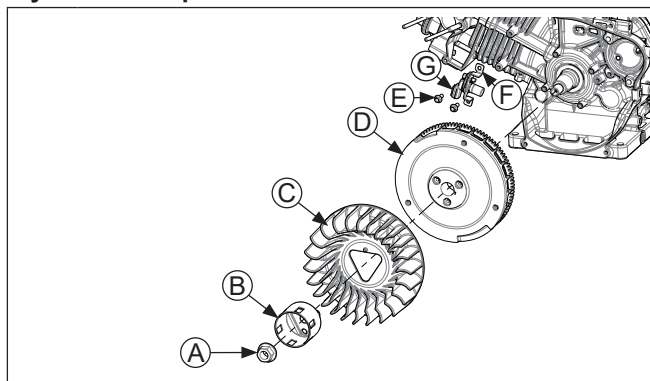
NOTE: Unless blower housing screen is damaged, disassembly from blower housing is unnecessary.

Remove screws securing blower housing screen to blower housing and remove screen.

Remove Blower Housing

1. A clamp secures part of wiring harness to blower housing. Note which wires are secured, remove screw and clamp from blower housing.
2. Remove screws securing blower housing to engine and remove blower housing.

Flywheel Components



| | | | |
|----------|--|----------|------------------------------------|
| A | Flywheel Retaining Nut | B | Drive Cup |
| C | Flywheel Fan | D | Flywheel |
| E | Crankshaft Position Sensor Bracket Screw | F | Crankshaft Position Sensor Bracket |
| G | Crankshaft Position Sensor | | |

Remove Crankshaft Position Sensor

NOTE: Do not remove sensor from bracket unless sensor is being replaced.

1. Unplug crankshaft position sensor electrical connector.
2. Remove upper screw securing crankshaft position sensor bracket to crankcase post.
3. Remove lower screw securing crankshaft position sensor bracket to crankcase post and also securing ground wire.
4. Remove crankshaft position sensor assembly.

Remove Flywheel

NOTE: Whenever possible, an impact wrench should be used to loosen flywheel retaining nut. A flywheel strap wrench may be used to hold flywheel when loosening or tightening flywheel retaining nut.

NOTE: Always use a puller to remove flywheel from crankshaft. Do not strike flywheel or crankshaft as these parts could become cracked or damaged.

1. Remove flywheel retaining nut.
2. Remove drive cup and fan from flywheel.
3. Remove flywheel from crankshaft using a suitable puller.
4. Remove flywheel key from crankshaft keyway.

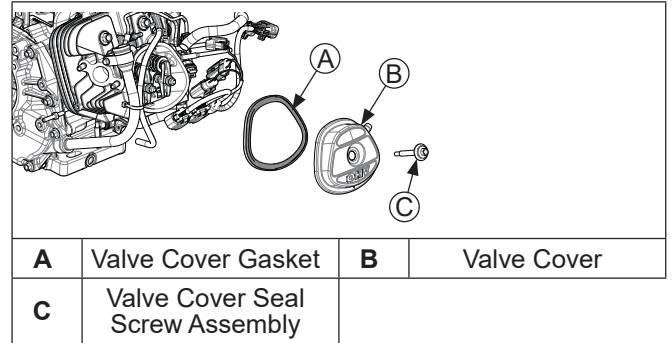
Inspection

Inspect flywheel for cracks and flywheel keyway for damage. Replace flywheel if it is cracked. Replace flywheel, crankshaft, and key if flywheel key is sheared or keyway is damaged.

Remove Wiring Harness

Disconnect oil level switch green wire from wiring harness; pull wiring harness through clip secured to crankcase. Pick up wiring harness from on top of crankcase, thread through hole and remove.

Remove Valve Cover



Remove valve cover seal screw assembly and remove valve cover and gasket from engine. Breather assembly is inside valve cover.

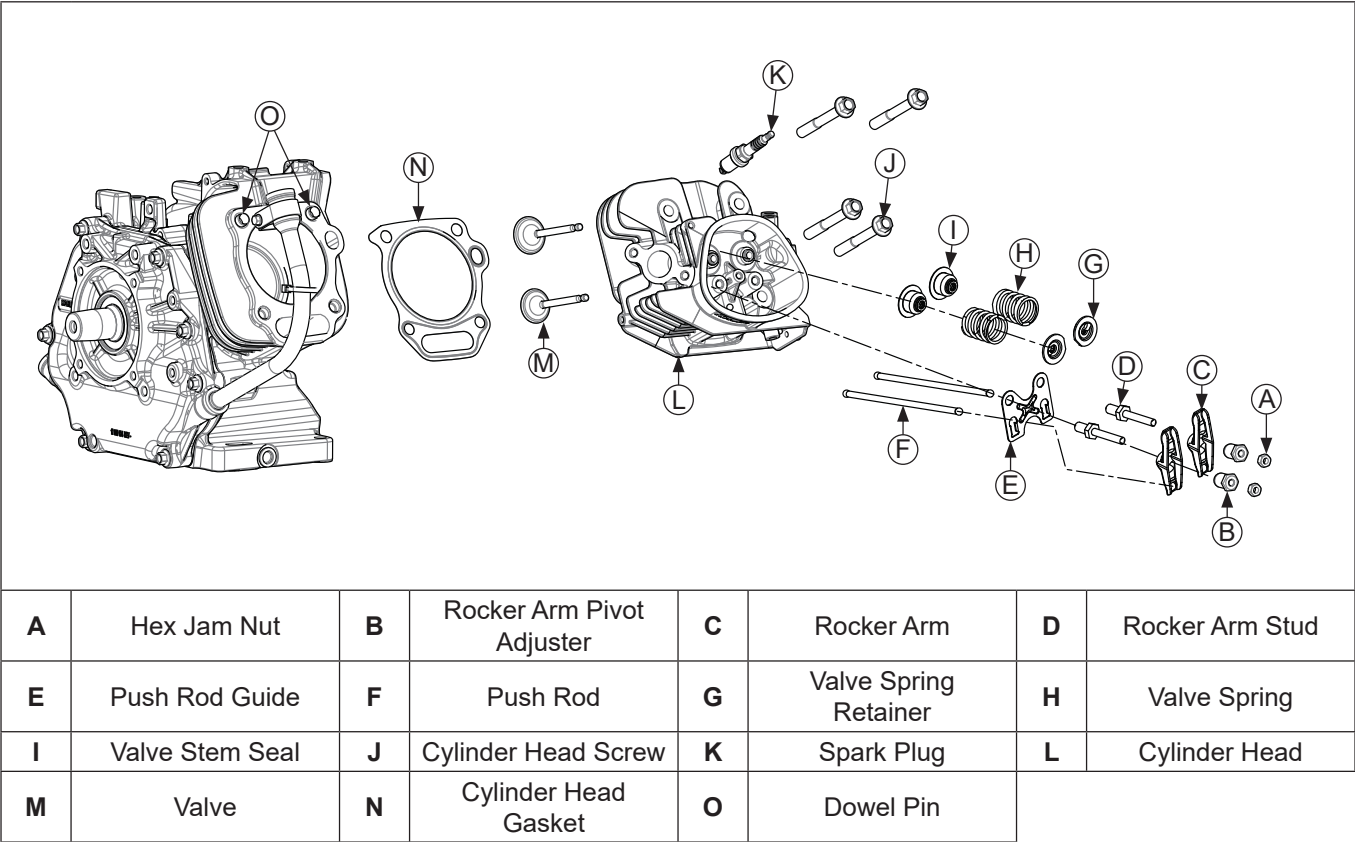
Breather System

Breather system is designed to control amount of oil in head area and still maintain necessary vacuum in crankcase.

When piston moves downward, crankcase gases are pushed past reed through mesh filter into intake system. Upward travel of piston closes reed and creates a low vacuum in lower crankcase. Any oil separated out through filter drains back into crankcase.

Disassembly/Inspection and Service

Cylinder Head Components



Remove Rocker Arms, Push Rods, and Cylinder Head Assembly

NOTE: Mark location of push rods and any other part removed being reused.

1. Loosen and remove rocker arm pivot adjuster and hex jam nuts. Remove rocker arms and push rods.
2. Remove spark plug.
3. Remove screws securing cylinder head.
4. Remove cylinder head, dowel pins, and cylinder head gasket.

Remove Valves

NOTE: Mark locations of any part removed being reused.

1. Supporting head of valve from below, depress valve spring retainer and valve spring until retainer can be released from valve stem. Remove valve spring and valve from head. Repeat this procedure for remaining valve.
2. Remove and replace valve stem seals whenever cylinder head is serviced or disassembled.

Inspection and Service

After cleaning, check flatness of cylinder head and corresponding top surface of crankcase, using a surface plate or precision straight edge and feeler gauge. Maximum allowable out of flatness is 0.1 mm (0.0039 in.).

Carefully inspect valve mechanism parts. Inspect valve springs and related hardware for excessive wear or distortion. Check valves and valve seat area or inserts for evidence of deep pitting, cracks, or distortion.

Check clearance of valve stems in guides. See valve details and specifications.

Hard starting, or loss of power accompanied by high fuel consumption may be symptoms of faulty valves. Although these symptoms could also be attributed to worn rings, remove and check valves first. After removal, clean valve heads, faces, and stems with a power wire brush.

Then, carefully inspect each valve for defects such as warped head, excessive corrosion, or worn stem end. Replace valves found to be in bad condition.

Disassembly/Inspection and Service

Valve Guides

If a valve guide is worn beyond specifications, it will not guide valve in a straight line. This may result in burnt valve faces or seats, loss of compression, and excessive oil consumption.

To check valve guide-to-valve stem clearance, thoroughly clean valve guide and, using a split-ball gauge, measure inside diameter of guide. Then, using an outside micrometer, measure diameter of valve stem at several points on stem where it moves in valve guide. Use largest stem diameter to calculate clearance by subtracting stem diameter from guide diameter. If intake or exhaust clearance exceeds specifications in Valve Specification table, determine whether valve stem or guide is responsible for excessive clearance.

If guides are within limits but valve stems are worn beyond limits, install new valves.

Valve Seat Inserts

Hardened steel alloy intake and exhaust valve seat inserts are press-fitted into cylinder head. Inserts are not replaceable but can be reconditioned if not too badly pitted or distorted. If cracked or badly warped, cylinder head should be replaced.

Recondition valve seat inserts following instructions provided with valve seat cutter being used. Final cut should be made with a 44.5° cutter as specified for valve seat angle. Cutting proper 45° valve face angle, as specified, and proper valve seat angle (44.5°) will achieve desired 0.5° (1.0° full cut) interference angle where maximum pressure occurs on outside diameters of valve face and seat.

Lapping Valves

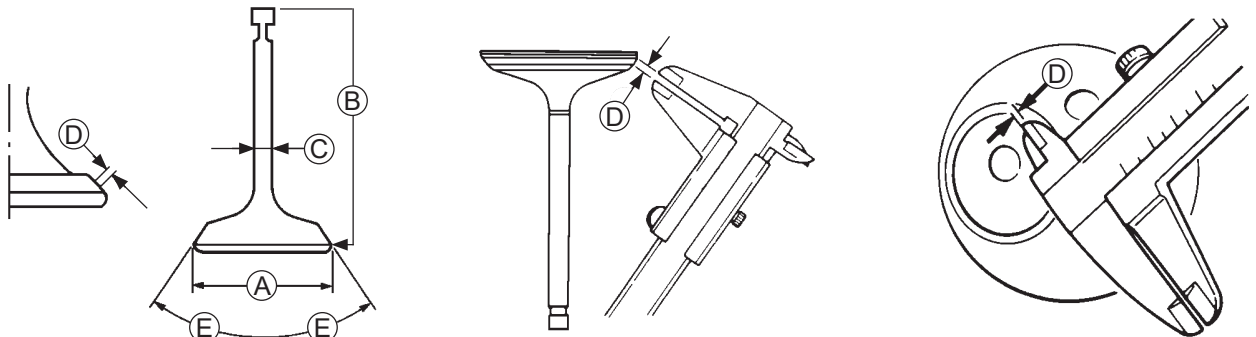
Reground or new valves must be lapped in, to provide proper fit. Use a hand valve lapping tool with suction cup for final lapping. Lightly coat valve face with fine grade of grinding compound, then rotate valve on seat with tool. Continue lapping until smooth surface is obtained on seat and on valve face. Thoroughly clean cylinder head in soap and hot water to remove all traces of grinding compound. After drying cylinder head, apply a light coating of SAE 10 oil to prevent rusting.

Valve Stem Seals

These engines use valve stem seals on intake and exhaust valves.

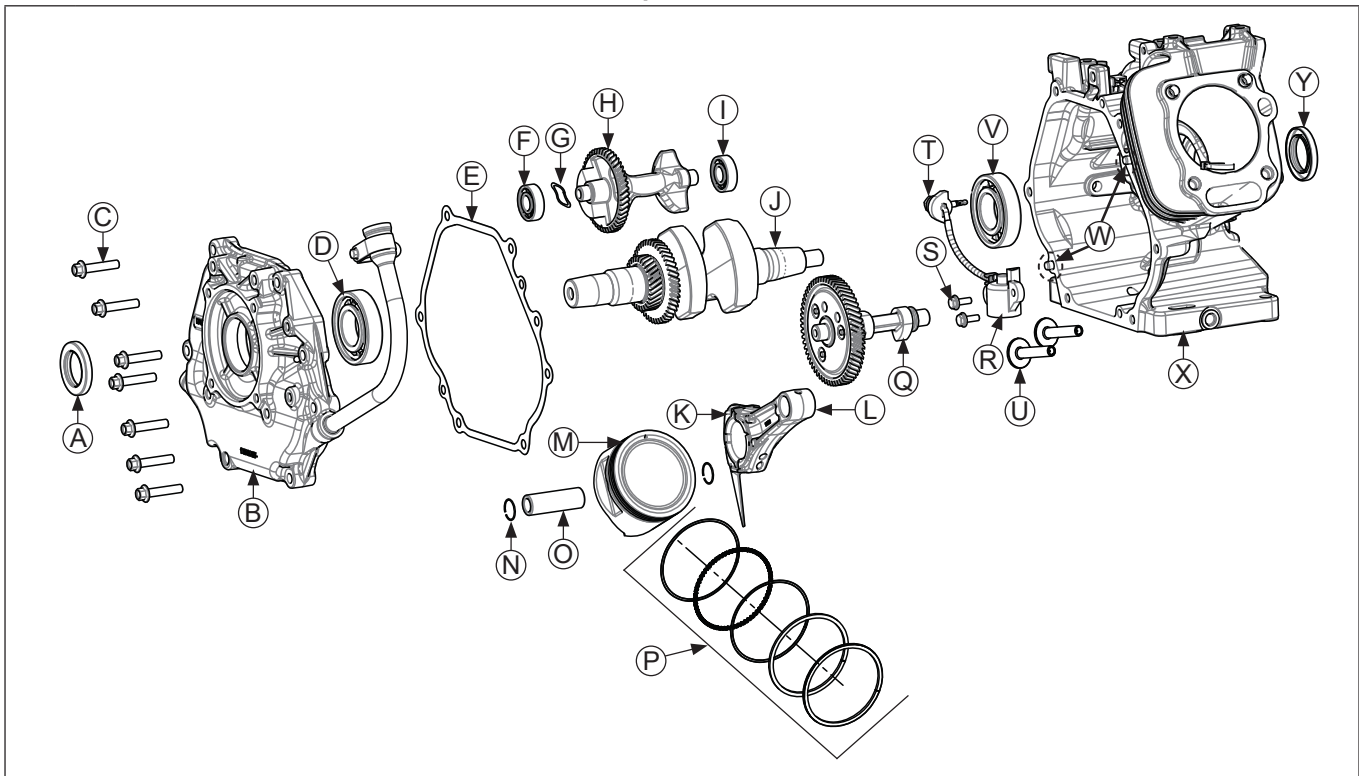
Always use new seals when valves are removed from cylinder head. Seals should also be replaced if deteriorated or damaged in any way. Never reuse old seals.

Valve Details

|  | | | |
|--|---------------------------|---|---|
| Valve Specifications | | | |
| Item | Dimension | Intake | Exhaust |
| A | Head Diameter | 35.875-36.125 mm (1.4124-1.4222 in.) | 32.875-33.125 mm (1.2943-1.3041 in.) |
| B | Valve Length | 86.175-86.375 mm (3.3927-3.4006 in.) | 86.341-86.541 mm (3.3993-3.4071 in.) |
| C | Stem Diameter | 6.560-6.575 mm (0.2583-0.2589 in.) | 6.545-6.560 mm (0.2577-0.2583 in.) |
| D | Face/Seat Width - Maximum | 1.5 mm (0.059 in.) | 1.5 mm (0.059 in.) |
| E | Face/Seat Angle | 45°-44.5° | 45°-44.5° |

Disassembly/Inspection and Service

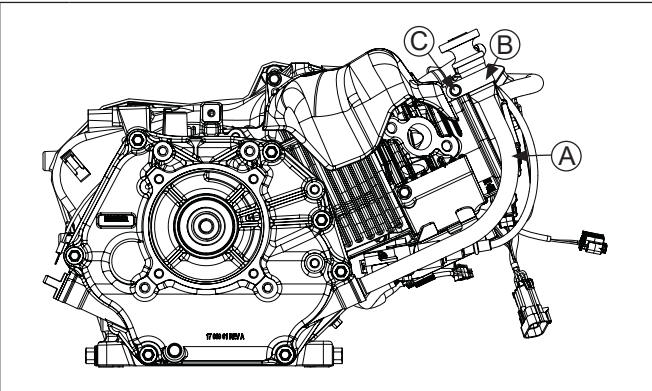
Crankcase/Crankshaft/Camshaft/Closure Plate Components



| | | | | | | | |
|----------|---------------------------------|----------|-------------------------------------|----------|-----------------------|----------|-----------------------|
| A | Closure Plate Oil Seal | B | Closure Plate | C | Screw | D | Closure Plate Bearing |
| E | Closure Plate Gasket | F | Closure Plate Balance Shaft Bearing | G | Wave Spring | H | Balance Shaft |
| I | Crankcase Balance Shaft Bearing | J | Crankshaft | K | Connector Rod End Cap | L | Connector Rod |
| M | Piston | N | Piston Pin Retainer | O | Piston Pin | P | Piston Ring Set |
| Q | Camshaft | R | Oil Sentry™ Level Switch | S | Screw | T | Oil Sentry™ Wire |
| U | Tappet | V | Crankcase Bearing | W | Dowel Pin | X | Crankcase |
| Y | Crankcase Oil Seal | | | | | | |

Remove Oil Fill Tube

Details



| | | | |
|---|---------------|---|-----------------------|
| A | Oil Fill Tube | B | Oil Fill Tube Bracket |
| C | Bracket Screw | | |

NOTE: Unless oil fill tube is damaged, disassembly from closure plate is unnecessary.

1. Remove bracket screw and oil fill tube bracket.
2. If necessary, remove tube from closure plate. If not, allow oil fill tube to remain in closure plate. Tube will be removed with closure plate as an assembly.

Remove Closure Plate

NOTE: Do not pry on gasket surface of crankcase or closure plate, as this can cause damage and leakage.

1. Remove screws securing closure plate to crankcase.
2. Remove closure plate, gasket, and dowel pins (if required) from crankcase.
3. Remove closure plate and oil fill tube as an assembly.
4. Remove shims from crankshaft.

Inspection

Inspect main bearing surface for wear or damage (refer to Specifications). Replace closure plate if required.

Remove Balance Shaft

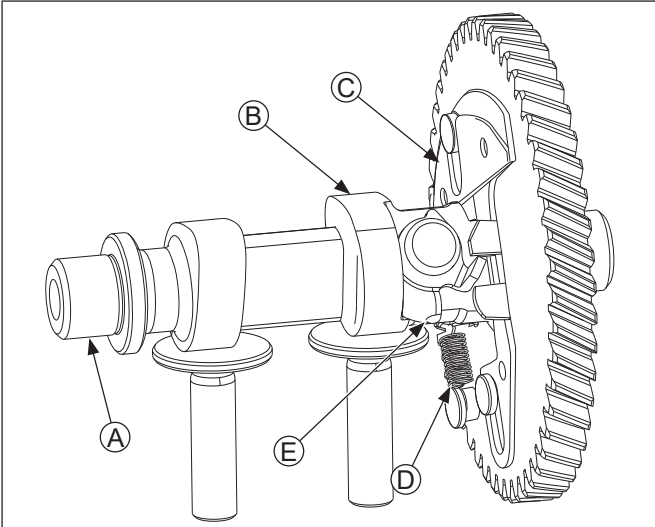
Remove balance shaft (with wave spring) by pulling it straight out of crankcase.

Remove Camshaft and Valve Tappets

1. Remove camshaft by pulling it straight out of crankcase.
2. Remove valve tappets by pulling them straight out of crankcase. Mark their positions.

Automatic Compression Release (ACR)

ACR Operation Details



| | | | |
|---|----------------------|---|------------------|
| A | Camshaft | B | Exhaust Cam Lobe |
| C | Decompression Weight | D | Return Spring |
| E | Arm | | |

ACR mechanism consists of a spring-loaded arm and sliding pin mounted to camshaft. When engine is rotating at low cranking speeds, arm holds pin so it protrudes above heel of exhaust cam. This holds exhaust valve off of its seat during first part of compression stroke.

After engine speed increases centrifugal force causes spring-loaded arm to move outward causing pin to retract. When in this position pin has no effect on exhaust valve and engine operates at full compression and power.

Benefits

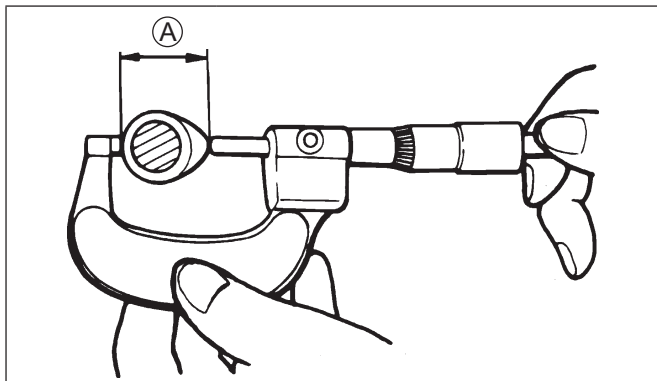
As a result of reduced compression at cranking speeds, several important benefits are obtained:

1. Electric start models can use a smaller starter and battery more practical for application.
2. ACR eliminates need for a spark retard/advance mechanism. ACR eliminates this kickback making manual starting safer.
3. Engines with ACR start much faster in cold weather than engines without ACR.
4. Engines with ACR can be started with worn or fouled spark plug. Engines without ACR are more difficult to start with those same spark plug.

Disassembly/Inspection and Service

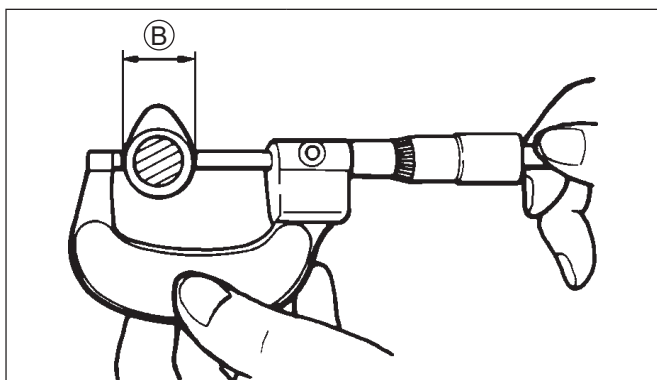
Inspection and Service

Dimension A



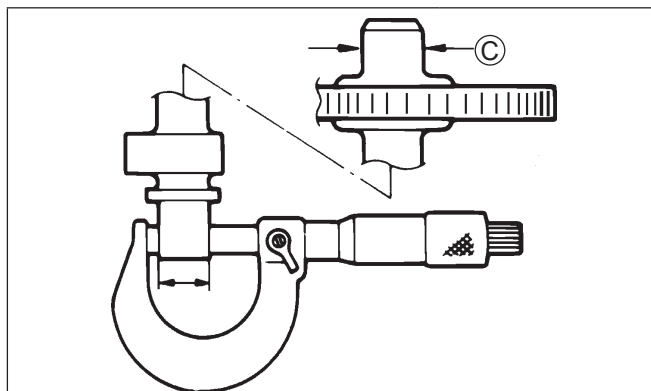
| Cam Lobe | | |
|----------|--------------------------|--------------------------|
| INTAKE | 32.286 mm (1.271 in.) | 32.032 mm (1.261 in.) |
| EXHAUST | 32.506 mm (1.280 in.) | 32.252 mm (1.270 in.) |

Dimension B



| Cam Lobe Specifications | | |
|-------------------------|-------------------------|-------------------------|
| Valve | Dimension B | Service Limit |
| INTAKE | 25.94 mm (1.021 in.) | 25.68 mm (1.011 in.) |
| EXHAUST | 25.94 mm (1.021 in.) | 25.68 mm (1.011 in.) |

Dimension C



| Camshaft Journal Specifications | |
|---------------------------------|---------------------------|
| Dimension C | Limit |
| 15.975 mm (0.6289 in.) | 15.900 mm (0.6260 in.) |

Inspect gear teeth of camshaft. If teeth are badly worn, chipped, or some are missing, replacement of camshaft will be necessary. If unusual wear or damage is evident on either lobe or mating tappet, camshaft and both tappets must be replaced. Check condition and operation of ACR mechanism.

Measure cam lobe profile, A and B, using an outside micrometer and compare with specifications listed.

Measure camshaft journals, C, which fit in ball bearings, for wear using a micrometer. Compare with specifications listed.

Remove Piston, Connecting Rod and Crankshaft

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

1. Remove screws securing end cap to connecting rod. Remove end cap. Carefully guiding connecting rod, slide piston and connecting rod from cylinder bore.
2. Remove crankshaft from crankcase.

Connecting Rod Inspection and Service

Check bearing area (big end) for excessive wear, score marks, running and side clearances (see Specifications and Tolerances). Replace rod and cap if scored or excessively worn.

Service replacement connecting rods are available in STD size and 0.25 mm (0.010 in.) undersize. 0.25 mm (0.010 in.) undersized rods have an identification marking on lower end of rod shank. Always refer to appropriate parts information to ensure correct replacements are used.

Disassembly/Inspection and Service

Piston and Rings Inspection

Scuffing and scoring of piston and cylinder wall occurs when internal engine temperatures approach welding point of piston. Temperatures high enough to do this are created by friction, which is usually attributed to improper lubrication and/or overheating of engine.

Normally, very little wear takes place in piston boss-piston pin area. If original piston and connecting rod can be reused after new rings are installed, original pin can also be reused but new piston pin retainers are required. Piston pin is included as part of piston assembly – if pin boss in piston or pin are worn or damaged, a new piston assembly is required.

Ring failure is usually indicated by excessive oil consumption and blue exhaust smoke. When rings fail, oil is allowed to enter combustion chamber where it is burned along with fuel. High oil consumption can also occur when piston ring end gap is incorrect because ring cannot properly conform to cylinder wall under this condition. Oil control is also lost when ring gaps are not staggered during installation.

When cylinder temperatures get too high, lacquer and varnish collect on pistons causing rings to stick, which results in rapid wear. A worn ring usually takes on a shiny or bright appearance.

Scratches on rings and piston are caused by abrasive material such as carbon, dirt, or pieces of hard metal. Detonation damage occurs when a portion of fuel charge ignites spontaneously from heat and pressure shortly after ignition. This creates 2 flame fronts, which meet and explode to create extreme hammering pressures on a specific area of piston. Detonation generally occurs from using low octane fuels.

Preignition, or ignition of fuel charge before timed spark can cause damage similar to detonation. Preignition damage is often more severe than detonation damage. Preignition is caused by a hot spot in combustion chamber such as glowing carbon deposits, blocked cooling fins, an improperly seated valve, or wrong spark plug.

Replacement pistons are available in STD bore size, and 0.25 mm (0.010 in.) oversize. Replacement pistons include new piston ring sets and new piston pins.

Replacement ring sets are also available separately for STD, and 0.25 mm (0.010 in.) oversize pistons. Always use new piston rings when installing pistons. Never use old rings.

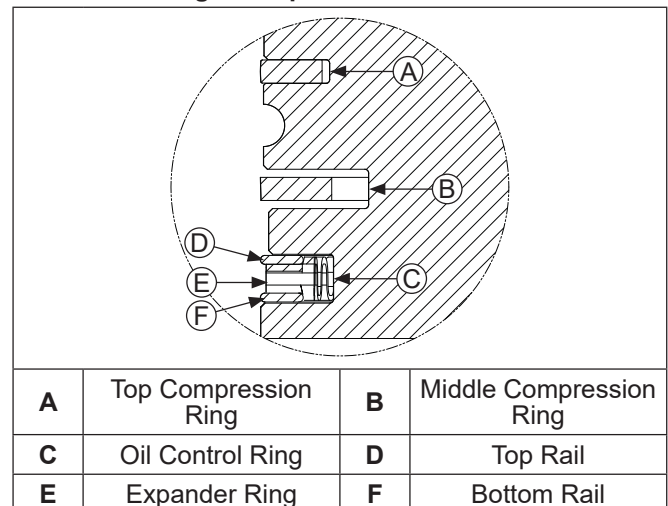
Some important points to remember when servicing piston rings:

1. Cylinder bore must be deglazed before service ring sets are used.
2. If cylinder bore does not need reboring and if old piston is within wear limits and free of score or scuff marks, old piston may be reused.
3. Remove old rings and clean up grooves. Never reuse old rings.
4. Before installing new rings on piston, place top 2 rings, each in turn, in its running area in cylinder bore and check end gap. Refer to Specifications.
5. After installing new compression (top and middle) rings on piston, check piston-to-ring side clearance. Refer to Specifications. If side clearance is greater than specified, a new piston must be used.

Piston and Rings

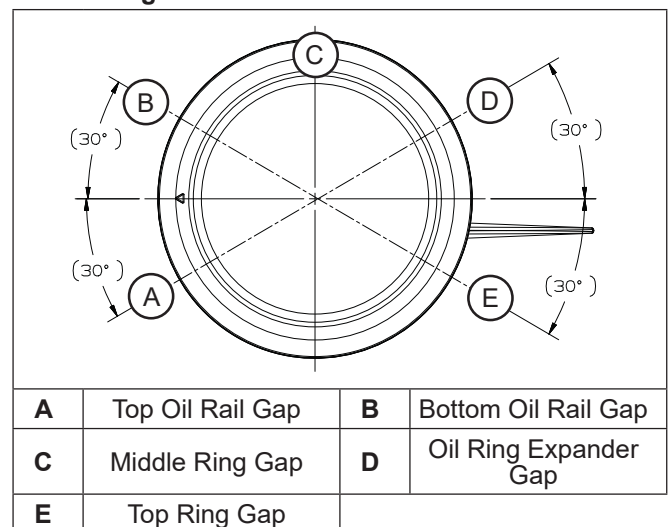
Inspection

Piston and Rings Components and Details



Install New Piston Rings

Piston Ring Orientation



Disassembly/Inspection and Service

NOTE: Rings must be installed correctly. Use a piston ring expander to install rings. Install bottom (oil control) ring first and top compression ring last.

To install new piston rings, proceed as follows:

1. Oil control ring (bottom groove): Install expander and then rails. Make sure ends of expander are not overlapped.
2. Middle compression ring (center groove): Install center ring using a piston ring installation tool. Make sure identification mark is up or colored dye stripe (if contained), is to left of end gap.
3. Top compression ring (top groove): Install top ring using a piston ring expander. Make sure identification mark is up or colored dye stripe (if contained), is to left of end gap.

Crankshaft Inspection and Service

Inspect gear teeth of crankshaft. If teeth are badly worn, chipped, or some are missing, replacement of crankshaft will be necessary.

Inspect crankshaft bearing surfaces for scoring, grooving, etc. Measure running clearance between crankshaft journals and their respective bearing bores. Use an inside micrometer or telescoping gauge to measure inside diameter of both bearing bores in vertical and horizontal planes. Use an outside micrometer to measure outside diameter of crankshaft main bearing journals. Subtract journal diameters from their respective bore diameters to get running clearances. Check results against values in Specifications and Tolerances. If running clearances are within specification, and there is no evidence of scoring, grooving, etc., no further reconditioning is necessary. If bearing surfaces are worn or damaged, crankcase and/or closure plate will need to be replaced.

Inspect crankshaft keyways. If worn or chipped, replacement of crankshaft will be necessary. Inspect crankpin for score marks or metallic pickup. Slight score marks can be cleaned with crocus cloth soaked in oil. If wear limits are exceeded, as stated in Specifications, it will be necessary to replace crankshaft.

Remove Oil Sentry™ System

1. Remove nut securing Oil Sentry™ lead wire grommet assembly in crankcase.
2. Pull grommet assembly from inside of crankcase.
3. Remove screws securing Oil Sentry™ level switch to crankcase. Remove switch assembly.

Remove Crankcase and Closure Plate Seals and Bearings

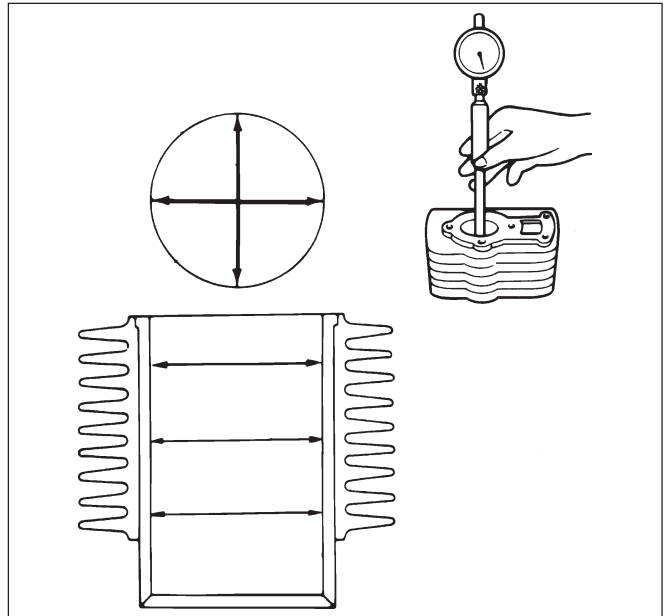
NOTE: Inspect bearings for signs of wear by rotating inner race and examine for marring or cracks. Check to make sure race moves easily and is not sloppy. If bearing is tight and rotates smoothly, removal is not necessary. If you feel any roughness or chattering or bearing is sloppy, it should be replaced.

1. Remove oil seal from crankcase.
2. Using a suitable press, push crankshaft bearing from crankcase.

3. Remove oil seal from closure plate.
4. Using a suitable press, push crankshaft bearing from closure plate.

Crankcase Inspection and Service

Cylinder Bore Detail



NOTE: A 0.25 mm (0.010 in.) oversize piston is available if resizing is selected. Initially, resize using a boring bar, then follow procedures for honing cylinder.

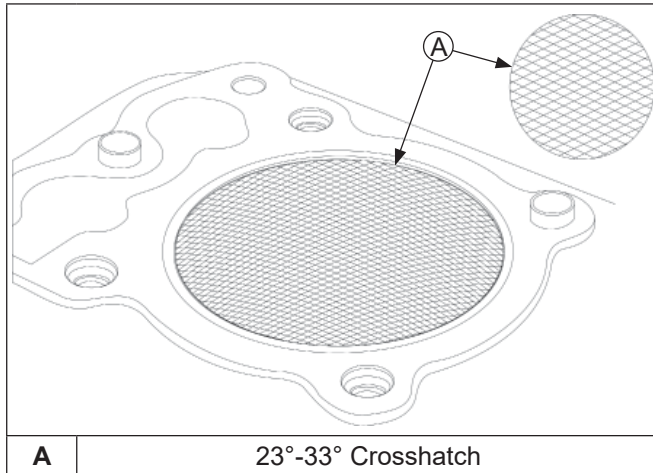
Check all gasket surfaces to make sure they are free of gasket fragments. Gasket surfaces must also be free of deep scratches or nicks.

Check cylinder bore for scoring. In severe cases, unburned fuel can cause scuffing and scoring of cylinder wall. It washes necessary lubricating oils off piston and cylinder wall. As raw fuel seeps down cylinder wall, piston rings make metal to metal contact with wall. Scoring of cylinder wall can also be caused by localized hot spots resulting from blocked cooling fins or from inadequate or contaminated lubrication.

If cylinder bore is badly scored, excessively worn, tapered, or out-of-round, resizing is necessary. Use an inside micrometer to determine amount of wear (refer to Specifications).

Honing

Crosshatch Detail



NOTE: Kohler pistons are custom-machined to exacting tolerances. When over-sizing a cylinder, it should be machined exactly 0.25 mm (0.010 in.) over new diameter (Specifications and Tolerances). Oversize Kohler replacement piston will then fit correctly.

While most commercially available cylinder hones can be used with either portable drills or drill presses, use of a low speed drill press is preferred as it facilitates more accurate alignment of bore in relation to crankshaft crossbore. Honing is best accomplished at a drill speed of about 250 RPM and 60 strokes per minute. After installing coarse stones in hone, proceed as follows:

1. Lower hone into bore and after centering, adjust stones so they are in contact with cylinder wall. Use of a commercial cutting-cooling agent is recommended.
2. With lower edge of each stone positioned even with lowest edge of bore, start drill and honing process. Move hone up and down while resizing to prevent formation of cutting ridges. Check size frequently.
3. When bore is within 0.064 mm (0.0025 in.) of desired size, remove coarse stones and replace them with burnishing stones. Continue with burnishing stones until bore is within 0.013 mm (0.0005 in.) of desired size and then use finish stones (220-280 grit) and polish bore to its final size. A crosshatch should be observed if honing is done correctly. Crosshatch should intersect at approximately 23°-33° off horizontal. Too flat an angle could cause rings to skip and wear excessively, and too steep an angle will result in high oil consumption.
4. After resizing, check bore for roundness, taper, and size. Use an inside micrometer, telescoping gauge, or bore gauge to take measurements. These measurements should be taken at 3 locations in cylinder – at top, middle, and bottom. Two measurements should be taken (perpendicular to each other) at each location.

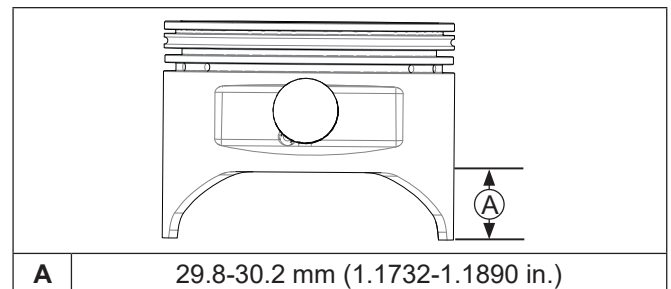
Clean Cylinder Bore After Honing

Proper cleaning of cylinder walls following boring and/or honing is very critical to a successful overhaul. Machining grit left in cylinder bore can destroy an engine in less than one hour of operation after a rebuild.

Final cleaning operation should always be a thorough scrubbing with a brush and hot, soapy water. Use a strong detergent capable of breaking down machining oil while maintaining a good level of suds. If suds break down during cleaning, discard dirty water and start again with more hot water and detergent. After scrubbing, rinse cylinder with very hot, clear water, dry it completely, and apply a light coating of engine oil to prevent rusting.

Measuring Piston-to-Bore Clearance

Piston Details



NOTE: Do not use a feeler gauge to measure piston-to-bore clearance, it will yield inaccurate measurements. Always use a micrometer.

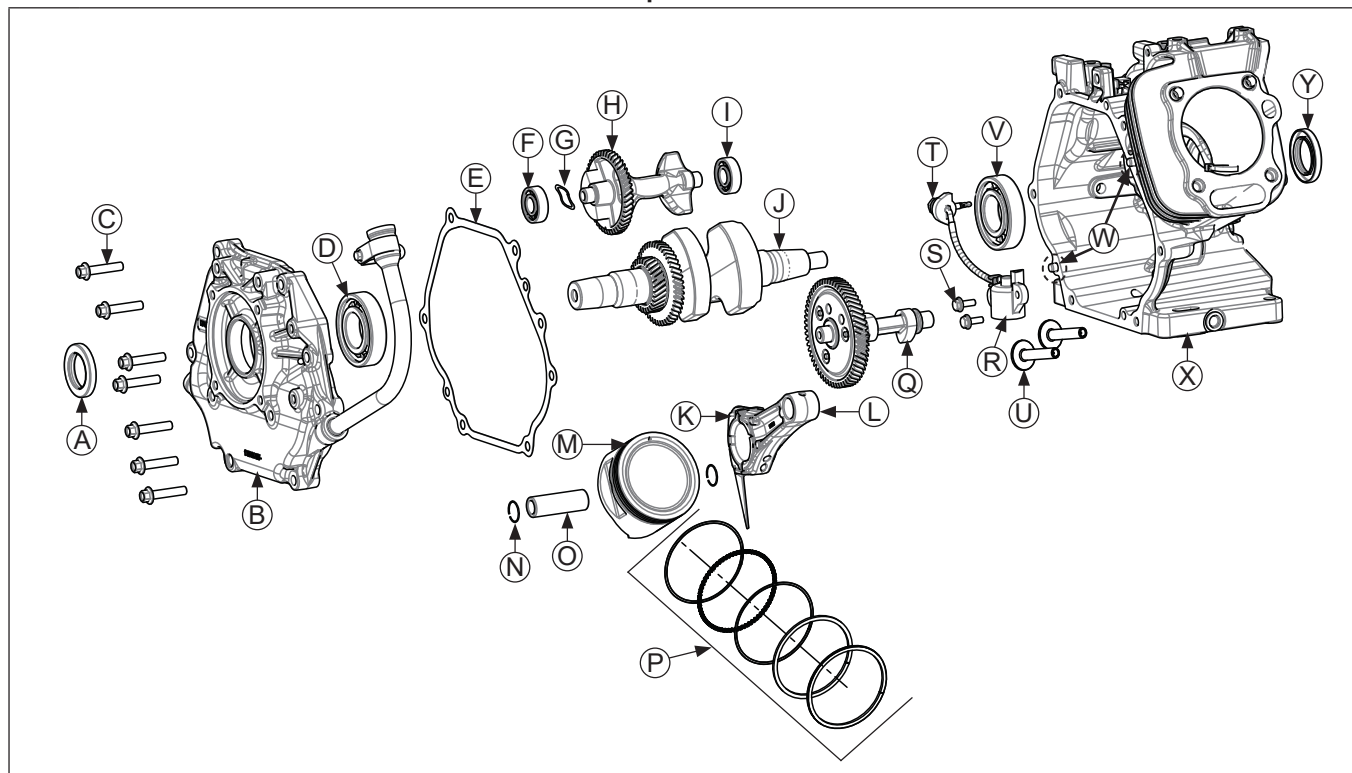
Before installing piston into cylinder bore, it is necessary that clearance be accurately checked. This step is often overlooked, and if clearances are not within specifications, engine failure will usually result.

Use following procedure to accurately measure piston-to-bore clearance:

1. Use a micrometer and measure diameter of piston above bottom of piston skirt and perpendicular to piston pin.
2. Use an inside micrometer, telescoping gauge, or bore gauge and measure cylinder bore. Take measurement approximately 7.0 mm (0.2760 in.) below top of bore and perpendicular to piston pin.
3. Piston-to-bore clearance is difference between bore diameter and piston diameter (step 2 minus step 1).

Reassembly

Crankcase/Crankshaft/Camshaft/Closure Plate Components



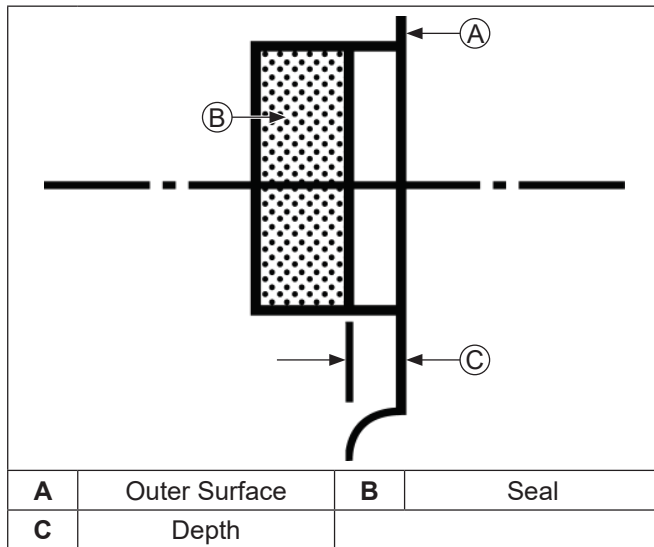
| | | | | | | | |
|----------|---------------------------------|----------|-------------------------------------|----------|-----------------------|----------|-----------------------|
| A | Closure Plate Oil Seal | B | Closure Plate | C | Screw | D | Closure Plate Bearing |
| E | Closure Plate Gasket | F | Closure Plate Balance Shaft Bearing | G | Wave Spring | H | Balance Shaft |
| I | Crankcase Balance Shaft Bearing | J | Crankshaft | K | Connector Rod End Cap | L | Connector Rod |
| M | Piston | N | Piston Pin Retainer | O | Piston Pin | P | Piston Ring Set |
| Q | Camshaft | R | Oil Sentry™ Level Switch | S | Screw | T | Oil Sentry™ Wire |
| U | Tappet | V | Crankcase Bearing | W | Dowel Pin | X | Crankcase |
| Y | Crankcase Oil Seal | | | | | | |

NOTE: Engines in this application have air cleaner, starter generator, in-tank fuel pump, EFI fuel filter, and all fuel lines supplied and installed by OEM. Refer to equipment manufacturer's manual for information on these components and before working on fuel system. Use only original equipment replacement parts.

NOTE: Make sure engine is assembled using all specified torque values, tightening sequences, and clearances. Failure to observe specifications could cause severe engine wear or damage. Always use new gaskets.

Install Crankcase Bearings and Oil Seals

Details



NOTE: Oil bearings liberally with engine oil when installing.

NOTE: In steps 3 and 4, position oil seals with manufacturer's identification marks visible and facing you.

1. Make sure there are no nicks, burrs, or damage in bores for bearings. Crankcase and closure plate must be clean.
2. Use an arbor press to make sure bearings are installed straight into their respective bores, until fully seated.
3. Using an appropriate seal driver, install oil seal into closure plate to depth of 8.2 mm (0.323 in.) from outer surface.
4. Using an appropriate seal driver, install oil seal into crankcase to depth of 0.0-1.0 mm (0.0-0.039 in.) from outer surface.
5. Apply a light coating of lithium grease to seal lips after installing.

Install Oil Sentry™ System

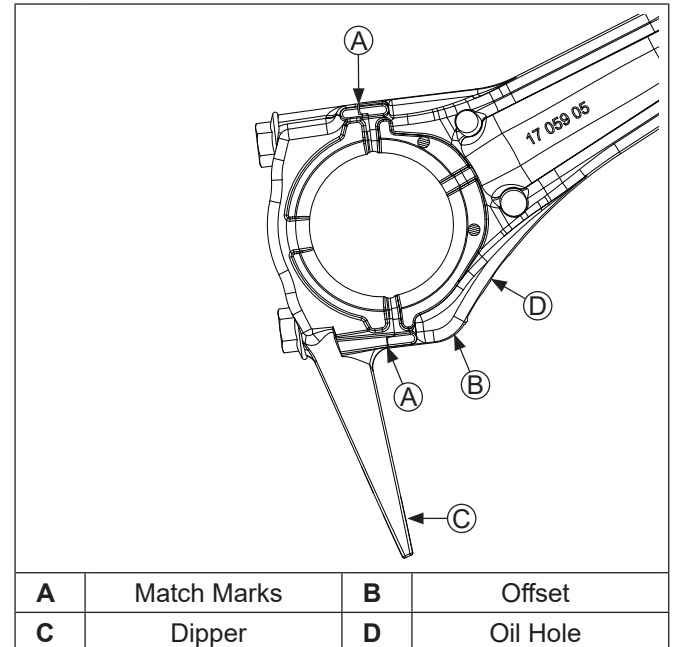
1. Mount Oil Sentry™ switch into crankcase housing using two M6x18 screws and torque to 8 N·m (71 in. lb.).
2. Route wire lead grommet assembly through crankshaft housing.
3. Install nut on grommet assembly external stud and torque to 10 N·m (89 in. lb.).

Install Crankshaft

Carefully slide flywheel end of crankshaft through main ball bearing and seal.

Install Connecting Rod with Piston and Rings

Connecting Rod Details

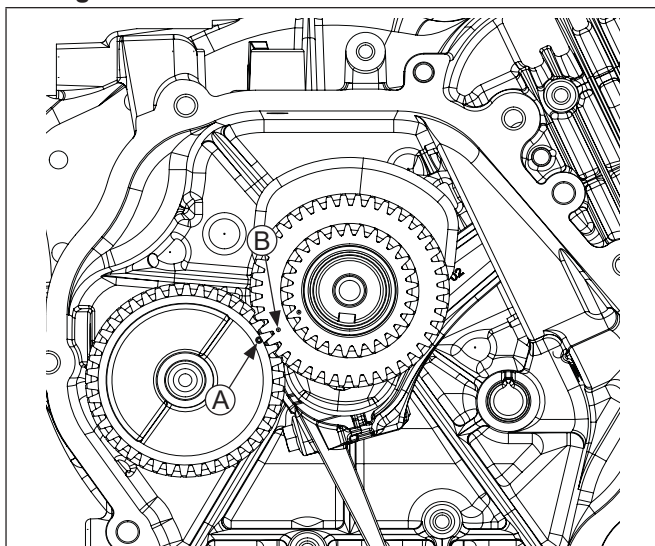


1. Make sure these are correct before installing.
 - a. Locating mark on piston is down.
 - b. Connecting rod offset is down and oil hole is in 4 o'clock position shown. Match marks should align as shown with dipper down.
2. If piston rings were removed, see Disassembly/Inspection and Service procedure to install rings.
3. Lubricate cylinder bore, piston, piston pin, and piston rings with engine oil. Compress rings using a piston ring compressor.
4. Lubricate crankshaft journal and connecting rod bearing surfaces with engine oil.
5. Ensure ▼ stamping on piston is facing down toward base of engine. Use a hammer handle or rounded wood dowel and gently tap piston into cylinder. Be careful oil ring rails do not spring free between bottom of ring compressor and top of cylinder.
6. Install connecting rod cap to connecting rod so dipper is down and match marks are aligned.
7. Torque both screws in increments to 20 N·m (177 in. lb.).

Reassembly

Install Balance Shaft

Timing Mark Detail

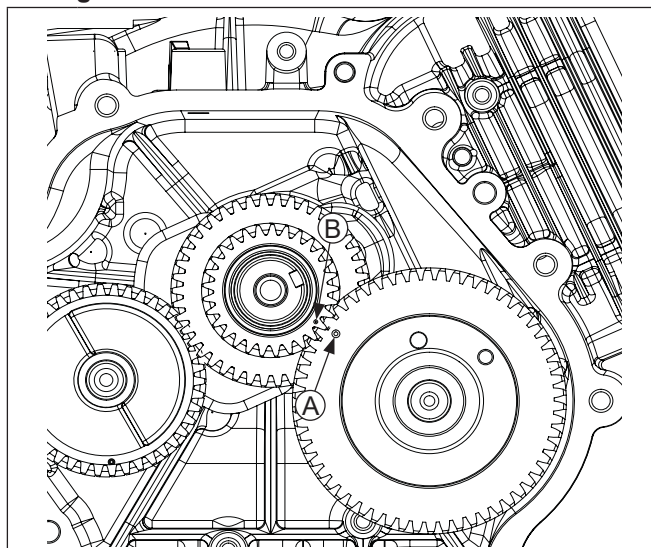


| | | | |
|----------|------------------------------|----------|--|
| A | Balance Shaft Timing Mark | B | Balance Shaft Drive Gear on Crankshaft Timing Mark |
|----------|------------------------------|----------|--|

1. Position crankshaft so timing mark on larger crankgear is in 8 o'clock position.
2. Install balance shaft (with wave spring), aligning timing mark with timing mark on larger crankgear.

Install Valve Tappets and Camshaft

Timing Mark Detail

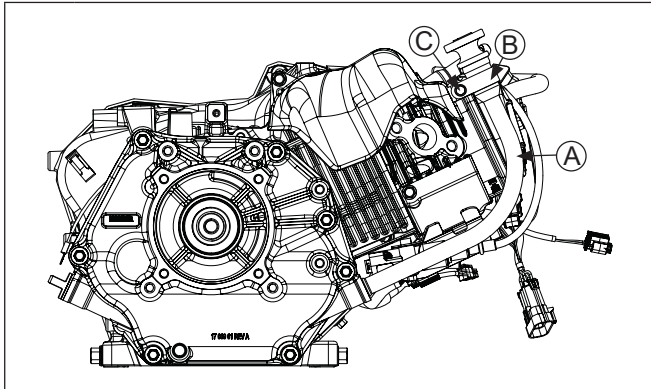


| | | | |
|----------|------------------------------|----------|---|
| A | Camshaft Gear Timing Mark | B | Camshaft Drive Gear on Crankshaft Timing Mark |
|----------|------------------------------|----------|---|

1. Lubricate face and stem of each tappet with engine oil. Install each into their respective bores.
2. Lubricate camshaft bearing surfaces and cam lobes as well as camshaft bore in crankcase with engine oil.
3. Rotate crankshaft to TDC so timing mark (dimple) on smaller crankgear is in 4 o'clock position. Install camshaft into crankcase, aligning timing marks on two gears.
4. Install original shims on crankshaft.

Install Oil Fill Tube

Details

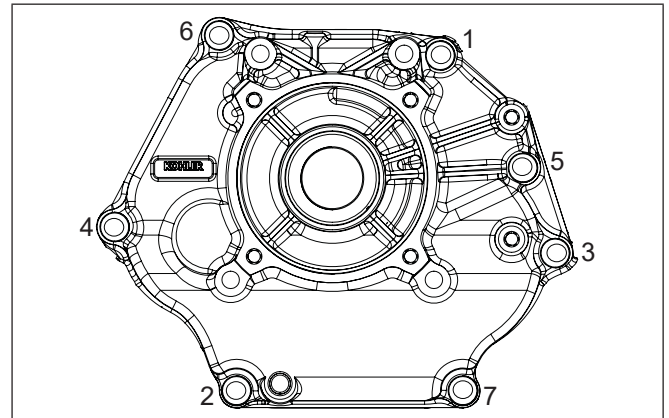


| | | | |
|----------|---------------|----------|-----------------------|
| A | Oil Fill Tube | B | Oil Fill Tube Bracket |
| C | Bracket Screw | | |

1. If oil fill tube was removed from closure plate, apply a small amount of Loctite® 620™ (or equivalent) to end of tube, then press into closure plate until tube bead seats in closure plate. Tube should be parallel to closure plate PTO face.
2. Place bracket over tube and secure with bracket screw. Tighten screw until bracket is tight all around tube; then torque to 5.4 N·m (48 in. lb.).

Install Closure Plate

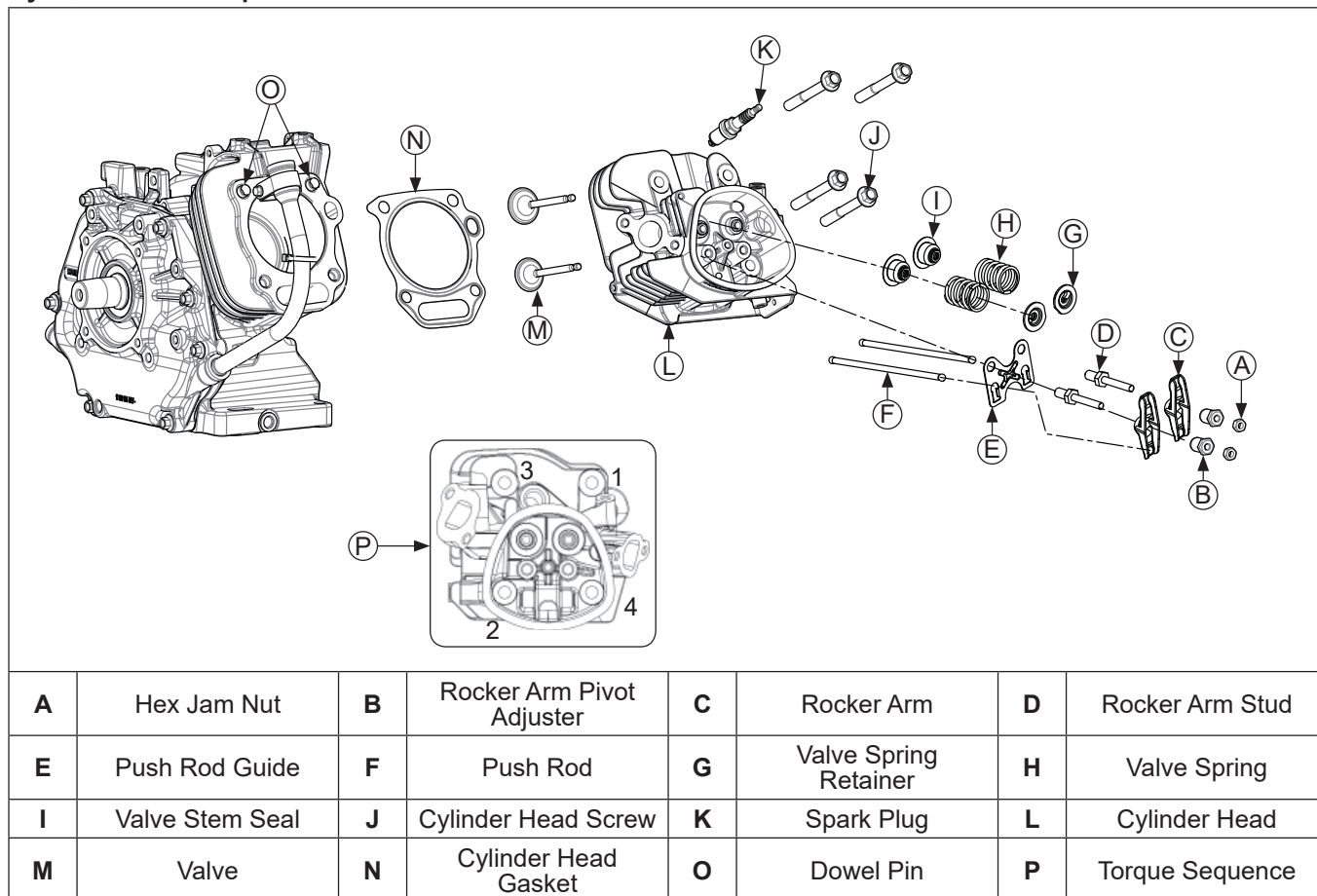
Torque Sequence



1. Check to make sure sealing surfaces of crankcase and closure plate are clean and free of nicks/burrs.
2. Install two dowel pins into locations shown in crankcase. Install new closure plate gasket (dry) onto dowel pins.
3. Install closure plate to crankcase. Carefully seat ends of camshaft and balance shaft into their mating bearings.
4. Install screws securing closure plate to crankcase. Torque screws in sequence shown to 24 N·m (212 in. lb.).

Reassembly

Cylinder Head Components



Assemble Cylinder Head

NOTE: Engine utilizes valve stem seals on valves. Always use a new seal when valves are installed in cylinder head. Never reuse old seals.

1. Install valves into their respective positions.
2. Install new valve seals on stem of valves.
3. Install valve springs and retainers into their respective locations in cylinder head. Support valve heads from underneath. Using hand pressure, compress each valve spring and slide each retainer onto valve stem to lock in place.

Install Cylinder Head

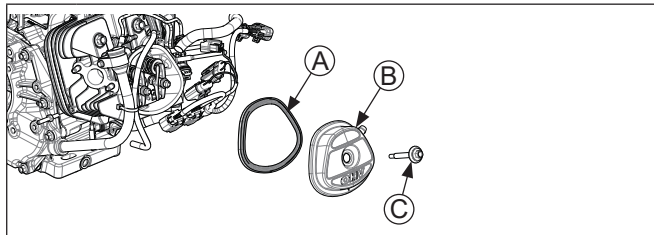
1. Check to make sure there are no nicks or burrs on sealing surfaces of cylinder head or crankcase.
2. Rotate crankshaft to position piston at TDC on compression stroke.
3. Install dowel pins into recesses around upper cylinder head bolt holes.
4. Install a new cylinder head gasket.
5. Apply clean engine oil under head of each cylinder head screw.
6. Install cylinder head and start screws. Finger tighten screws, then torque screws in increments using sequence shown. Torque screws first to 25 N·m (221 in. lb.), then finally to 57.5 N·m (509 in. lb.).

Install Push Rods and Rocker Arms

NOTE: Push rods should always be installed in original location.

1. Identify proper position of each push rod. Dip ends of push rods in engine oil and install them in their respective locations, seating each into tappet socket.
2. Install push rod guide plate, aligning holes for rocker arm studs. Screw in rocker arm studs and torque to 13.6 N·m (120 in. lb.).
3. Assemble rocker arms, rocker arm pivot adjusters, and hex jam nuts onto studs and push rods. Finger tighten rocker arm pivot jam locknuts.
4. Adjust valve tappet clearance as follows:
 - a. Make sure piston is still at top of compression stroke.
 - b. Insert a flat feeler gauge between rocker arm and valve stem. Recommended valve to rocker arm clearance for both intake and exhaust is 0.076-0.127 mm (0.003-0.005 in.)(Cold).
 - c. Adjust clearance as required by loosening hex jam nut and turning rocker arm pivot adjuster.
Turn clockwise to decrease clearance.
Turn counterclockwise to increase clearance.
 - d. Hold rocker arm pivot adjuster from turning and tighten hex jam nut. Torque hex jam nut to 10 N·m (89 in. lb.).
 - e. Recheck clearance is correct.
5. Set gap of a new spark plug to 1.11 mm (0.044 in.).
6. Install spark plug in cylinder head and torque to 27 N·m (20 ft. lb.).

Install Valve Cover



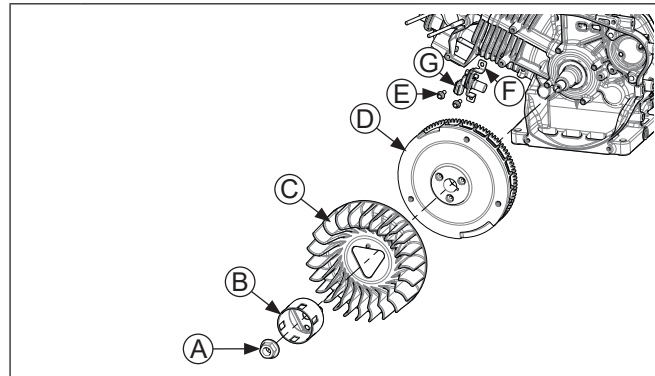
| | | | |
|----------|---------------------------------|----------|-------------|
| A | Valve Cover Gasket | B | Valve Cover |
| C | Valve Cover Seal Screw Assembly | | |

1. Install a new valve cover gasket onto valve cover.
2. Position valve cover/gasket assembly on head. Install screw and washer; torque screw to 10 N·m (89 in. lb.).

Install Wiring Harness

Route wiring harness through castings on crankcase. Direct green wire toward oil level switch. Feed this wire through clip secured to crankcase. Connect oil level switch green wire to wiring harness.

Flywheel Components



| | | | |
|----------|--|----------|------------------------------------|
| A | Flywheel Retaining Nut | B | Drive Cup |
| C | Flywheel Fan | D | Flywheel |
| E | Crankshaft Position Sensor Bracket Screw | F | Crankshaft Position Sensor Bracket |
| G | Crankshaft Position Sensor | | |

Install Flywheel



CAUTION

Damaging Crankshaft and Flywheel can cause personal injury.

Using improper procedures can lead to broken fragments. Broken fragments could be thrown from engine. Always observe and use precautions and procedures when installing flywheel.

NOTE: Before installing flywheel make sure crankshaft taper and flywheel hub bore are clean, dry, and completely free of lubricants. Presence of lubricants can cause flywheel to be over stressed and damaged when nut is torqued to specification.

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

1. Install woodruff key into keyway of crankshaft. Make sure key is properly seated and parallel with taper of shaft.
2. Install flywheel onto crankshaft, being careful not to shift position of woodruff key.
3. Install fan bosses into matching holes in flywheel.
4. Position drive cup on flywheel, engaging boss on its base with corresponding hole in fan. Hold in position and install nut. Finger tighten to keep cup indexed.
5. Use a flywheel holding tool and torque wrench to tighten flywheel nut. Torque nut to 113 N·m (1000 in. lb.).

Reassembly

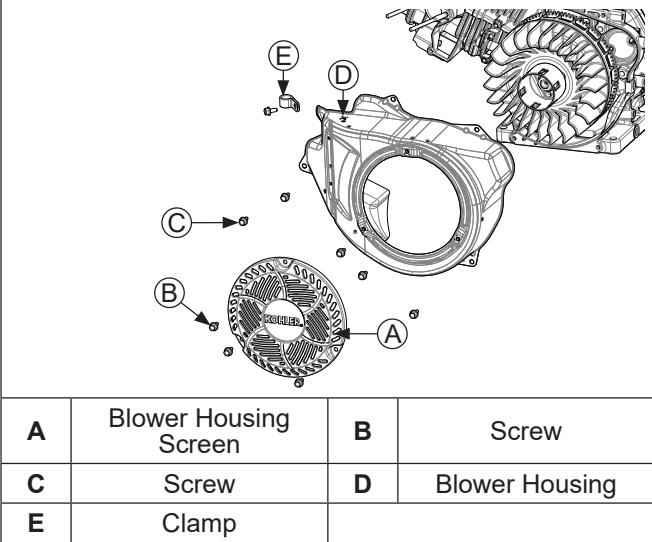
Install Crankshaft Position Sensor

NOTE: Ensure all parts are clean, undamaged and free of debris and make sure electrical connectors have seal in place.

NOTE: When mounting ground wire on bottom screw of bracket, ensure ground wire is routed outside and away from flywheel.

1. Install crankshaft position sensor to bracket. Torque screw to 4.2 N·m (37 in. lb.).
2. Install crankshaft position sensor and bracket assembly to crankcase posts.
3. Secure bracket assembly to crankcase posts. Torque bracket screws to 7.3 N·m (65 in. lb.).
4. Push electrical connector on crankshaft position sensor making sure a good connection is made.

Blower Housing Components



Install Blower Housing

Install blower housing on crankcase with screws. Torque screws to 10 N·m (89 in. lb.).

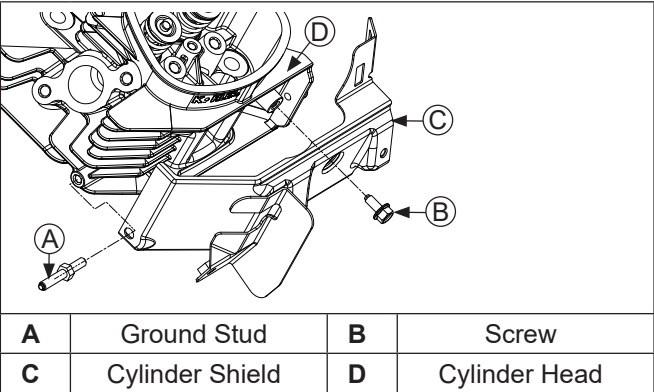
Install Blower Housing Screen

Install blower housing screen on blower housing using screws. Torque screws to 7.3 N·m (65 in. lb.).

Install Wiring Harness Clamp

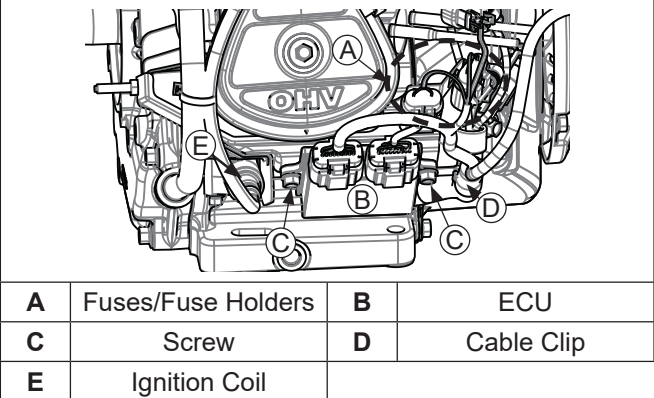
Insert wiring harness into clamp and install clamp with wiring harness to blower housing. Tighten screw securely.

Install Cylinder Shield



1. Install cylinder shield on cylinder head; secure with ground stud and screw as shown. Torque stud and screw to 8 N·m (71 in. lb.).
2. If removed, install ignition coil onto cylinder shield. Torque screw to 10.2 N·m (90 in. lb.).
3. Plug connector into ignition coil.

Fuses and ECU Components

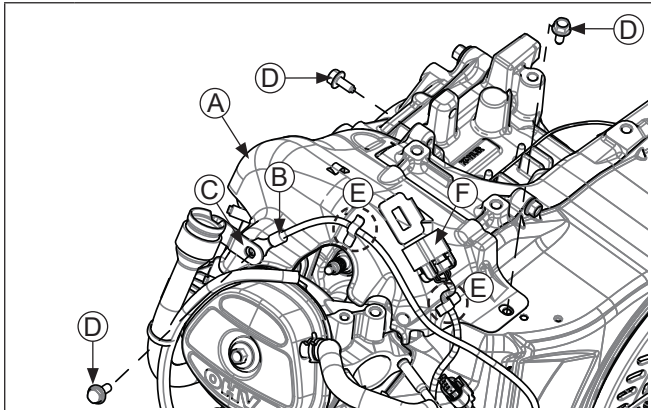


Install Electronic Control Unit (ECU)

NOTE: ECU pins should be coated with a thin layer of electrical grease to prevent fretting and corrosion and may need to be reapplied if ECU is being reused.

1. Connect Black and Grey electrical connectors. Connectors and ECU are keyed in such a way so they cannot be installed incorrectly.
2. Install ECU to cylinder shield using screws. Wire harness clip secures with screw closest to flywheel. Torque screws to 8 N·m (71 in. lb.).
3. Install fuses into holders on cylinder shield.

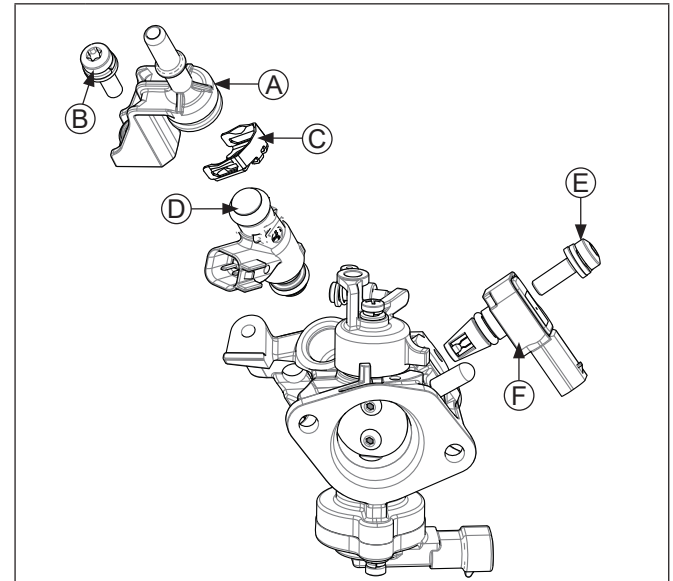
Install Upper Heat Shield and Engine Temperature Sensor



| | | | |
|----------|-----------------------|----------|---------------------------|
| A | Upper Heat Shield | B | Engine Temperature Sensor |
| C | Dipstick Tube Bracket | D | Screw |
| E | Clip | F | Oxygen Sensor Connector |

1. Position upper heat shield on crankcase and start 2 screws securing to crankcase. Do not tighten screws at this time.
2. Position engine temperature sensor between dipstick tube bracket and upper heat shield; start screw to secure. Torque this screw to 11.9 N·m (105 in. lb.).
3. Fully tighten and torque 2 screws securing shield to crankcase to 6.2 N·m (55 in. lb.) into new holes or 4.0 N·m (35 in. lb.) into used holes.
4. Install engine temperature wire under upper heat shield clip. Install oxygen sensor wire under upper heat shield clip.

Install Fuel Injector and TMAP



| | | | |
|----------|----------------------|----------|---------------|
| A | Fuel Injector Cap | B | Screw |
| C | Metal Retaining Clip | D | Fuel Injector |
| E | Screw | F | TMAP |

Install Temperature/Manifold Absolute Pressure (TMAP) Sensor

NOTE: Ensure all parts are clean, undamaged, and free of debris and make sure electrical connector has seal in place.

1. Lightly oil TMAP sensor O-ring and push sensor into bore in throttle body.
2. Torque screw to 7.3 N·m (65 in. lb.).
3. Push electrical connector on TMAP sensor making sure a good connection is made. Slide down lock tab.

Install Fuel Injector

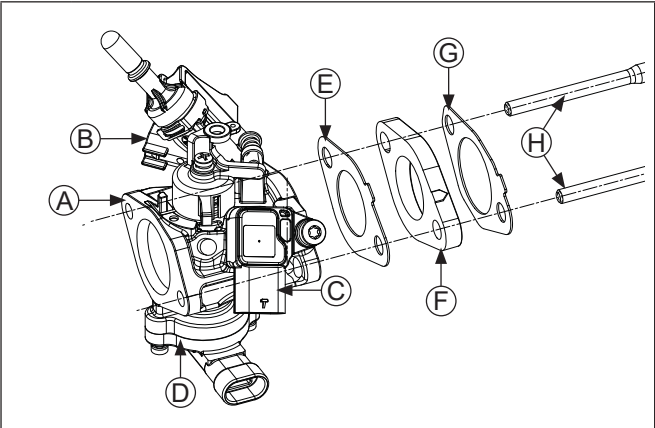
NOTE: Ensure all parts are clean, undamaged, and free of debris and make sure electrical connectors have seal in place.

NOTE: O-rings and retaining clip should be replaced any time fuel injector is separated from its normal mounting position.

1. Lightly lubricate fuel injector O-rings with clean engine oil.
2. Push retaining clip onto fuel injector, aligning clip.
3. Press fuel injector cap onto fuel injector until retaining clip snaps into place.
4. Press fuel injector into bore in throttle body and rotate to original position, as noted in Disassembly/Inspection and Service.
5. Install fuel injector cap screw into throttle body and torque to 7.3 N·m (65 in. lb.).
6. Push electrical connector on fuel injector making sure a good connection is made.

Reassembly

Install Throttle Body Assembly

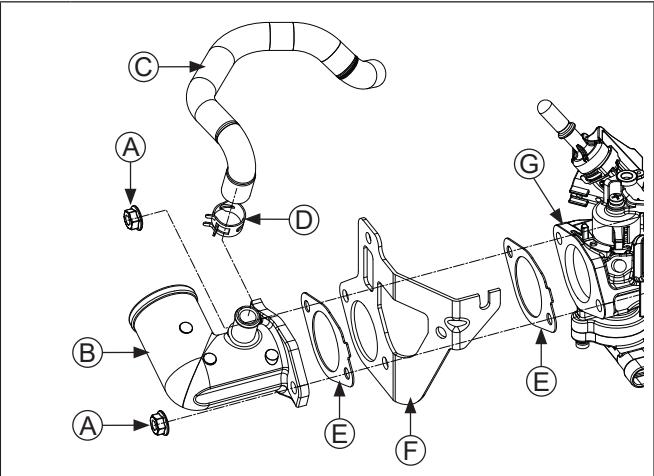


| | | | |
|---|-----------------------------------|---|--------------------------------|
| A | Throttle Body | B | Fuel Injector |
| C | TMAP | D | Throttle Position Sensor (TPS) |
| E | Insulator to Throttle Body Gasket | F | Insulator |
| G | Insulator to Cylinder Head Gasket | H | Intake Studs |

NOTE: Ensure all parts are clean, undamaged, and free of debris and make sure electrical connector has seal in place.

1. Install new insulator to cylinder head gasket, insulator, and insulator to throttle body gasket as shown.
Ensure notched section of each gasket is outward and points to flywheel side.
Ensure arrow on insulator points toward cylinder head.
2. Install throttle body on studs.
3. Push electrical connector onto throttle position sensor (TPS) making sure a good connection is made.

Install Air Inlet Elbow



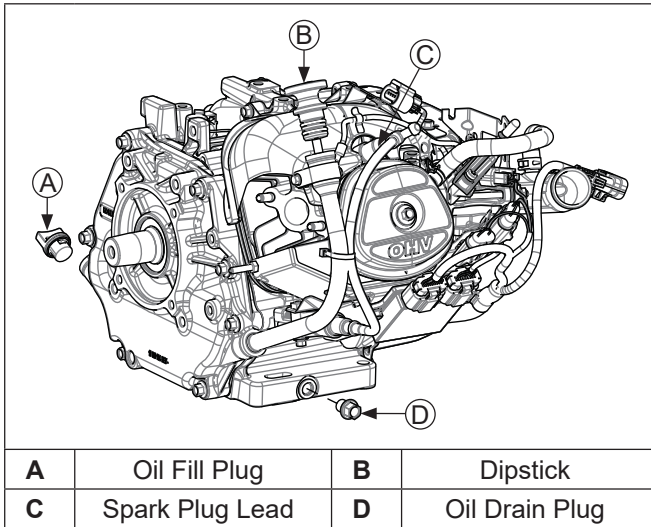
| | | | |
|---|---------------------------|---|------------------|
| A | Nut | B | Air Inlet Elbow |
| C | Breather Hose with Sleeve | D | Clamp |
| E | Throttle Body Gasket | F | Governor Bracket |
| G | Throttle Body | | |

1. Install a new throttle body gasket onto mounting studs followed by air inlet elbow.
2. Install governor bracket onto mounting studs followed by a new throttle body gasket.
Ensure notched section of each gasket is outward and points to flywheel side.
3. Install air inlet elbow onto mounting studs and secure with nuts. Torque nuts to 8 N·m (71 in. lb.).
4. Attach breather hose onto air inlet elbow connection port; position hose clamp to secure. Connect opposite end of breather hose to valve cover.

Oxygen Sensor

Install oxygen sensor, torque to 18 N·m (159 in. lb.), and connect to wire harness.

External Engine Components



Connect Spark Plug Lead

Connect lead to spark plug. Secure lead to dipstick tube with a new wire tie.

Prepare Engine for Operation

NOTE: If ECU, throttle body, TPS, or fuel pump were replaced, an ECU Reset and TPS Learn is required. Refer to EFI System, ECU Reset and TPS Learn procedure.

Engine is now reassembled. Before starting or operating engine be sure to do following:

1. Make sure all hardware is properly torqued.
2. Make sure oil drain plugs, oil fill plugs and Oil Sentry™ wire lead bushing are tightened securely.
3. Fill crankcase with correct oil. Refer to Maintenance and Lubrication System for oil recommendations and procedures.
4. Ensure all electrical connectors are installed and secure.
5. Make sure all fuel and vent lines are connected. Refer to equipment manufacturer's manual for Reassembly information.
6. Reinstall engine into application and test operation. Refer to equipment manufacturer's manual for details.



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Pagination Page

⚠ DANGER

- See General Warnings on page 1-2.

⚠ WARNING

- See General Warnings on page 1-2.

GENERAL INFORMATION

⚠ WARNING

- To prevent damage to the ECU, never mix the black and gray connectors that attach to it. The black connector is tethered to the ECU mounting plate to help avoid installing it in the gray port.

This section contains the information required to correctly troubleshoot the gasoline vehicle. In addition to troubleshooting, this section contains general information on the electrical system and the circuits of the electrical system.

ACCESSORIES

For certain powered accessories, use the 9-pin connector located behind the instrument panel.

LOW OIL WARNING LIGHT

NOTE: When the key switch is placed in the ON position, the Low Oil Warning Light will illuminate for approximately 3 seconds as a bulb check function.

If the Low Oil Warning Light comes ON due to low oil level, and oil is added to correct the issue, the Low Oil Warning Light will still remain ON. Cycle the key switch OFF and ON to reset the Low Oil Warning Light.

The gasoline vehicle is equipped with a low oil warning light (4), located at the top of the instrument panel. If the warning light comes on, oil should be checked and added to the engine as necessary before continuing to use the vehicle. **See following CAUTION.** The vehicle should never be driven when the low oil warning light remains on. If the warning light goes on and off, the vehicle may be driven, but oil should be added at the first opportunity. The light will flash repeatedly to indicate a possible problem with the electronic fuel injection (EFI) system. If the oil level is correct and the warning light stays on, have a trained technician check the vehicle.

CAUTION

- Failure to add oil immediately when the low oil warning light stays on may result in permanent engine damage.

GROUND LOCATIONS

Electrical grounds are located at the following areas:

- **At the Battery:** The starter/generator, voltage regulator, ECU, throttle position sensor and fuel pump module all connect to the main wire harness and goes to the B- battery terminal.
- **Between Engine and Battery:** The engine and chassis each have a separate lead that connects to the main wire harness and goes to the B- battery terminal.

- **Top of Fuel Tank:** The fuel tank has a lead that connects to the main wire harness and goes to the B– battery terminal.

FEATURES OF THE ELECTRONIC FUEL INJECTION (EFI) SYSTEM

- Open-loop system (i.e. oxygen sensor not used)
- Controls fuel pump, fuel injector, oil lamp
- Inputs: Manifold Absolute Pressure (MAP), engine block temperature, ignition timing
- Blink fault codes through the Low Oil Warning Lamp
- Separate EFI wire harness
- The ECU and throttle body/fuel injector assembly are matched pairs

TROUBLESHOOTING GUIDE

The following troubleshooting guides will be helpful in identifying operating difficulties should they occur. The guides include the symptom, probable cause(s) and suggested checks. The procedures used in making these checks can be found in the referenced sections of the maintenance and service manual.

ECU ERROR CODES (DISPLAYED BY THE LOW OIL WARNING LIGHT)

Failure Mode Table – When Ignition Is Initially Switched ON

| DISPLAY MODE | CONDITION | LAMP CONTROL |
|--------------|----------------|-------------------------------|
| Blink Code | No Failure | Step 1: Lamp ON Two Seconds |
| | | Step 2: Lamp OFF Four Seconds |
| | | Step 3: Lamp OFF |
| | Detect Failure | Step 1: Lamp ON Two Seconds |
| | | Step 2: Lamp OFF Four Seconds |
| | | Step 3: Display Blink Code |

Failure Mode Table – After Ignition Has Been In ON Position (i.e. During Use of Vehicle)

| DISPLAY MODE | CONDITION | LAMP CONTROL |
|--------------|----------------|-------------------------------|
| Blink Code | No Failure | Step 1: Lamp OFF |
| | Detect Failure | Step 1: Lamp OFF Four Seconds |
| | | Step 2: Display Blink Code |

Error Codes – ECU

| BLINK CODE | CODE DESCRIPTION | CORRECTIVE ACTION |
|------------|--|---|
| 21 | Low Battery Voltage | Check battery voltage. Charge/replace battery as necessary. |
| 22 | MAP Sensor: Open or Shorted Connection | Check connector at ECU & Throttle module. If connection is made and no corrosion is present, replace ECU and Throttle Module. |
| 23 | Temperature Sensor: Open or Shorted Connection | Check connector at ECU & Throttle module. If connection is made and no corrosion is present, replace ECU and Throttle Module. |
| 31 | Fuel Pump: Open Connection | Check fuel pump and fuel system. Check electrical connections at ECU, Throttle module and fuel pump. |
| 41 | Fuel Injector: Open Connection | Check connector at ECU & Throttle module. If connection is made and no corrosion is present, replace ECU and Throttle Module. |
| 51 | Ignition Pulse: Open Connection | Check spark plug, coil, ECU. Replace failed components. |

NOTE: If codes 22, 23, and 41 blink in-sequence, the gray plug is disconnected from the ECU.

If no codes blink, the black plug is disconnected from the ECU.

GASOLINE POWERTRAIN

| TROUBLESHOOTING GUIDE | | |
|--|---|--|
| SYMPTOM | POSSIBLE CAUSES | CORRECTIVE ACTION |
| Engine does not start easily. | Spark plug is partially fouled or in poor condition | Clean or replace |
| | Spark plug is damaged or loose | Replace or tighten |
| | Incorrect spark plug gap | Adjust gap |
| | Spark plug wire is damaged or loose | Replace or reconnect |
| | Loose or bad wire connection at ignition coil, EFI sensors, or ECU | Test Procedures 13 – <i>Ignition Spark</i> or 15 – <i>Ignition Coil</i> or 4 – <i>EFI System (ECU and Sensors)</i> |
| | Intermittent ignition coil failure | Test Procedures 13 – <i>Ignition Spark</i> and 15 – <i>Ignition Coil</i> |
| | Low fuel level in fuel tank | Refill |
| | Fuel line pinched or clogged | Clean or replace |
| | Poor fuel quality or contaminated fuel | Replace |
| | Fuel pump malfunction; fuel pressure to throttle body too low | Section 22 — Kohler ECH440 - Fuel System |
| | Water or dirt in the fuel system and/or throttle body/fuel injector; dirty or clogged fuel filter | Section 22 — Kohler ECH440 - Fuel System |
| | Throttle body dirty or improperly adjusted | Clean or adjust. Section 22 — Kohler ECH440 - Fuel System |
| | Low cylinder compression | Section 28 — Subaru EX-40 - Engine |
| | Cylinder head bolts not tighten properly | Check and retighten. Section 28 — Subaru EX-40 - Engine |
| | Intake or exhaust valve not sealing | Repair. Section 28 — Subaru EX-40 - Engine |
| | Incorrect valve clearance | Adjust. Section 28 — Subaru EX-40 - Engine |
| | Vacuum leak | Retighten hardware or replace gasket(s) |
| | Starter/generator belt is slipping | Belt Tension Adjustment for EFI Engines on page 27-13 |
| Engine starts but does not run smoothly. | Spark plug is fouled or in poor condition | Section 28 — Subaru EX-40 - Engine |
| | Spark plug wire is damaged or loose | Section 28 — Subaru EX-40 - Engine |
| | Intermittent ignition coil failure | Test Procedures 13 – <i>Ignition Spark</i> and 15 – <i>Ignition Coil</i> |
| | Water or dirt in the fuel system and/or throttle body/fuel injector; dirty or clogged fuel filter | Section 22 — Kohler ECH440 - Fuel System |
| | Fuel pump malfunction; fuel pressure to throttle body too low | Section 22 — Kohler ECH440 - Fuel System |

TABLE CONTINUED ON NEXT PAGE

| TROUBLESHOOTING GUIDE | | |
|----------------------------------|--|--|
| SYMPTOM | POSSIBLE CAUSES | CORRECTIVE ACTION |
| Engine turns but fails to start. | Fuel tank is empty | Section 22 — Kohler ECH440 - Fuel System |
| | Fuel line or filter clogged | Section 22 — Kohler ECH440 - Fuel System |
| | Fouled spark plug | Section 28 — Subaru EX-40 - Engine |
| | Spark plug wire damaged or loose | Section 28 — Subaru EX-40 - Engine |
| | Loose or bad wire connection at ignition coil, EFI sensors, or ECU | Test Procedures 13 – <i>Ignition Spark</i> or 15 – <i>Ignition Coil</i> or 4 – <i>EFI System (ECU and Sensors)</i> |
| | Ignition coil failed | Test Procedures 13 – <i>Ignition Spark</i> and 15 – <i>Ignition Coil</i> |
| | Kill circuit grounded | Test Procedures and 5 – <i>Key Switch (Engine Kill Circuit)</i> |
| | Fuel pump malfunction or failure | Section 22 — Kohler ECH440 - Fuel System |
| Engine overheats. | Fan screen is partially blocked or plugged | Section 28 — Subaru EX-40 - Engine |
| | Governor is improperly adjusted | Section 22 — Kohler ECH440 - Fuel System |
| | Excessive back pressure in exhaust | Check and clean or replace |
| | Fuel/air mixture is too lean; check EFI | Section 22 — Kohler ECH440 - Fuel System |
| | Overloading | Reduce to rated load |
| | Poor quality engine oil | Replace |
| Engine pre-ignites. | Excessive carbon deposits on piston head or in combustion chamber | Section 28 — Subaru EX-40 - Engine |
| | Spark plug heat range is incorrect | Section 28 — Subaru EX-40 - Engine |
| | Unsuitable or contaminated fuel | Section 22 — Kohler ECH440 - Fuel System |
| Loss of engine power. | Exhaust valve is restricted with carbon deposit | Section 28 — Subaru EX-40 - Engine |
| | Muffler or exhaust pipe restricted with carbon or other substance | Section 23 — Kohler ECH440 - Exhaust System |
| | Ignition coil failed | Test Procedures 13 – <i>Ignition Spark</i> and 15 – <i>Ignition Coil</i> |
| | Air filter is dirty or clogged | Section 22 — Kohler ECH440 - Fuel System |
| | Governor is improperly adjusted | Section 22 — Kohler ECH440 - Fuel System |
| | Throttle linkage out of adjustment | Section 22 — Kohler ECH440 - Fuel System |
| | Low cylinder compression | Section 28 — Subaru EX-40 - Engine |
| | Spark plug failed | Section 28 — Subaru EX-40 - Engine |
| | Restricted fuel flow | Section 22 — Kohler ECH440 - Fuel System |
| | Torque converter is not backshifting properly | Section 31 — Subaru EX-40 - Clutches |

TABLE CONTINUED ON NEXT PAGE

| TROUBLESHOOTING GUIDE | | |
|--|--|--|
| SYMPTOM | POSSIBLE CAUSES | CORRECTIVE ACTION |
| Spark plug fouls repeatedly. | Incorrect plug | Section 28 — Subaru EX-40 - Engine |
| | Spark plug wire is damaged | Section 28 — Subaru EX-40 - Engine |
| | Unsuitable fuel, or incorrect (rich) fuel mixture | Section 22 — Kohler ECH440 - Fuel System |
| | Ignition coil failed | Test Procedures 13 – <i>Ignition Spark</i> and 15 – <i>Ignition Coil</i> |
| | Dirt entering combustion chamber | Check intake system for leaks. Section 22 — Kohler ECH440 - Fuel System |
| | Rings are heavily worn, low cylinder pressure | Section 28 — Subaru EX-40 - Engine |
| Starter fails to operate. | Neutral lockout switch is in the MAINTENANCE position | Place switch in the OPERATE position. |
| | Fuse is blown | Test Procedure 2 – <i>Fuse Inspection</i> |
| | Battery is dead | Test Procedure 1 – <i>Battery</i> |
| | Starter control circuit is not operating | Test Procedure 4 – <i>Key Switch (Start Circuit)</i> |
| | Starter/generator failed | Test Procedure 11 – <i>Starter/Generator (Starter Function)</i> |
| | Starter solenoid failed | Test Procedure 7 – <i>Solenoid</i> |
| | Accelerator pedal limit switch failed | Test Procedure 6 – <i>Throttle Position Sensor (TPS)</i> |
| | Key switch failed | Test Procedure 4 – <i>Key Switch (Start Circuit)</i> |
| | Neutral lockout limit switch failed | Test Procedure 9 – <i>Transaxle Limit Switch</i> |
| | Loose or broken wire in starter/generator circuit | Section 20 — Kohler ECH440 - Electrical Components Starter/Generator on page 20-4 |
| | Cylinder and/or crankcase flooded with fuel | Section 22 — Kohler ECH440 - Fuel System |
| | | |
| Starter/generator does not charge battery. | Loose or broken wire in the starter/ generator circuit | Test Procedure 10 – <i>Starter/Generator (Generator Function)</i> |
| | Generator field coil is shorted | Test Procedure 10 – <i>Starter/Generator (Generator Function)</i> |
| | Brushes are worn or commutator is dirty | Section 20 — Kohler ECH440 - Electrical Components Starter/Generator on page 20-4 |
| | Starter/generator belt is loose or slipping | Section 20 — Kohler ECH440 - Electrical Components Belt Tension Adjustment for EFI Engines on page 27-13 |
| | Voltage regulator failed | Test Procedure 12 – <i>Voltage Regulator</i> |
| | Battery failed | Test Procedure 1 – <i>Battery</i> |

TABLE CONTINUED ON NEXT PAGE

| TROUBLESHOOTING GUIDE | | |
|---|--|---|
| SYMPTOM | POSSIBLE CAUSES | CORRECTIVE ACTION |
| Transmission does not engage or disengage smoothly. | Transmission shifter linkage is binding or is out of adjustment | Section 18 — Gasoline Vehicle - Transaxle |
| | Insufficient (low) level of lubricant or wrong type of lubricant in transmission | Section 18 — Gasoline Vehicle - Transaxle |
| | Internal gears are damaged or worn | Section 18 — Gasoline Vehicle - Transaxle |
| | Dog clutch jammed or broken | Section 18 — Gasoline Vehicle - Transaxle |
| Excessive vehicle vibration. | Engine mounting nuts or bolts are loose | Section 28 — Subaru EX-40 - Engine |
| | Snubber on frame is worn or damaged | Section 28 — Subaru EX-40 - Engine |
| | Loose muffler mounting hardware | Section 23 — Kohler ECH440 - Exhaust System |
| | Damaged drive belt or starter belt | Section 31 — Subaru EX-40 - Clutches |
| | Damaged drive clutch | Section 31 — Subaru EX-40 - Clutches |
| | Damaged starter/generator pulley | Section 20 — Kohler ECH440 - Electrical Components Starter/Generator on page 20-4 |
| | RPM setting is incorrect | Section 22 — Kohler ECH440 - Fuel System Engine RPM Adjustment on page 22-9 |
| Clutches do not shift smoothly. | Drive belt is worn, cracked, glazed, or frayed | Section 31 — Subaru EX-40 - Clutches |
| | Drive clutch malfunction | Section 31 — Subaru EX-40 - Clutches |
| | Governor is sticking | Section 18 — Gasoline Vehicle - Transaxle |
| Engine won't stop running. | Kill circuit wire is disconnected from the ignition coil | Test Procedure |
| | Accelerator pedal linkage out of adjustment causing engine kill limit switch not to activate | Section 22 — Kohler ECH440 - Fuel System |
| | Fuel mixture is too lean; check EFI | Section 22 — Kohler ECH440 - Fuel System |
| | Throttle stop screw out of adjustment at governor arm | Section 22 — Kohler ECH440 - Fuel System |

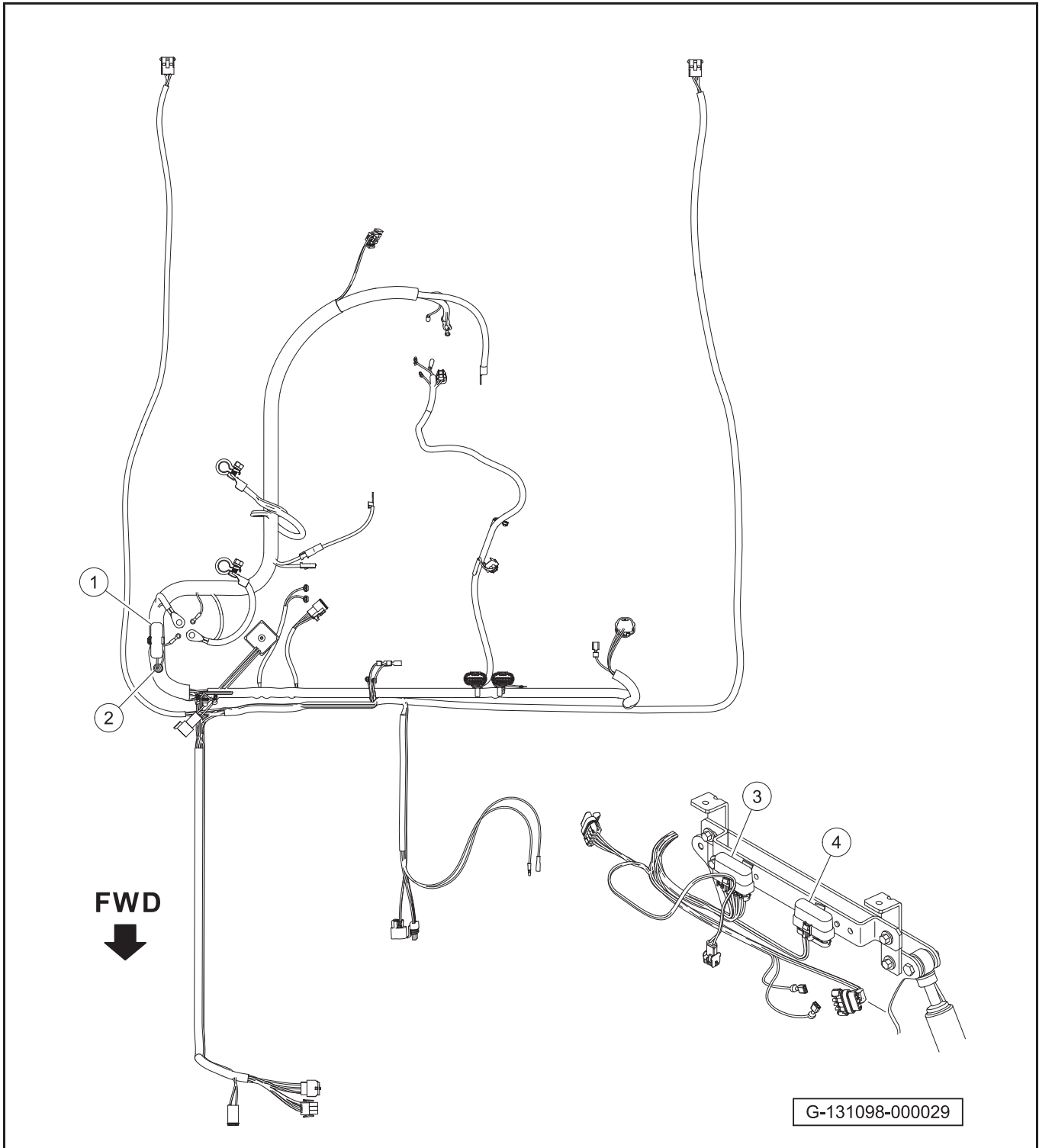
FUSE LOCATIONS

Figure 26-1 Fuse Locations

See Fuse and Relay Locations on page 19-5.

| CALLOUT NUMBER | DESCRIPTION |
|----------------|--|
| 1 | Fuse Holder <ul style="list-style-type: none"> • 10A Fuse • 5A Fuse • 20A Fuse |
| 2 | 2A Fuse |
| 3 | Fuse Holder <ul style="list-style-type: none"> • 7.5A Fuse - Stereo, Visage • 4A Fuse - Accent/Logo and Brake Lights • 3A Fuse - Headlights, Taillights |
| 4 | Fuse Holder <ul style="list-style-type: none"> • 10A Fuse - Horn, Turn Signal |

SONIC WELD AND DIODE LOCATIONS

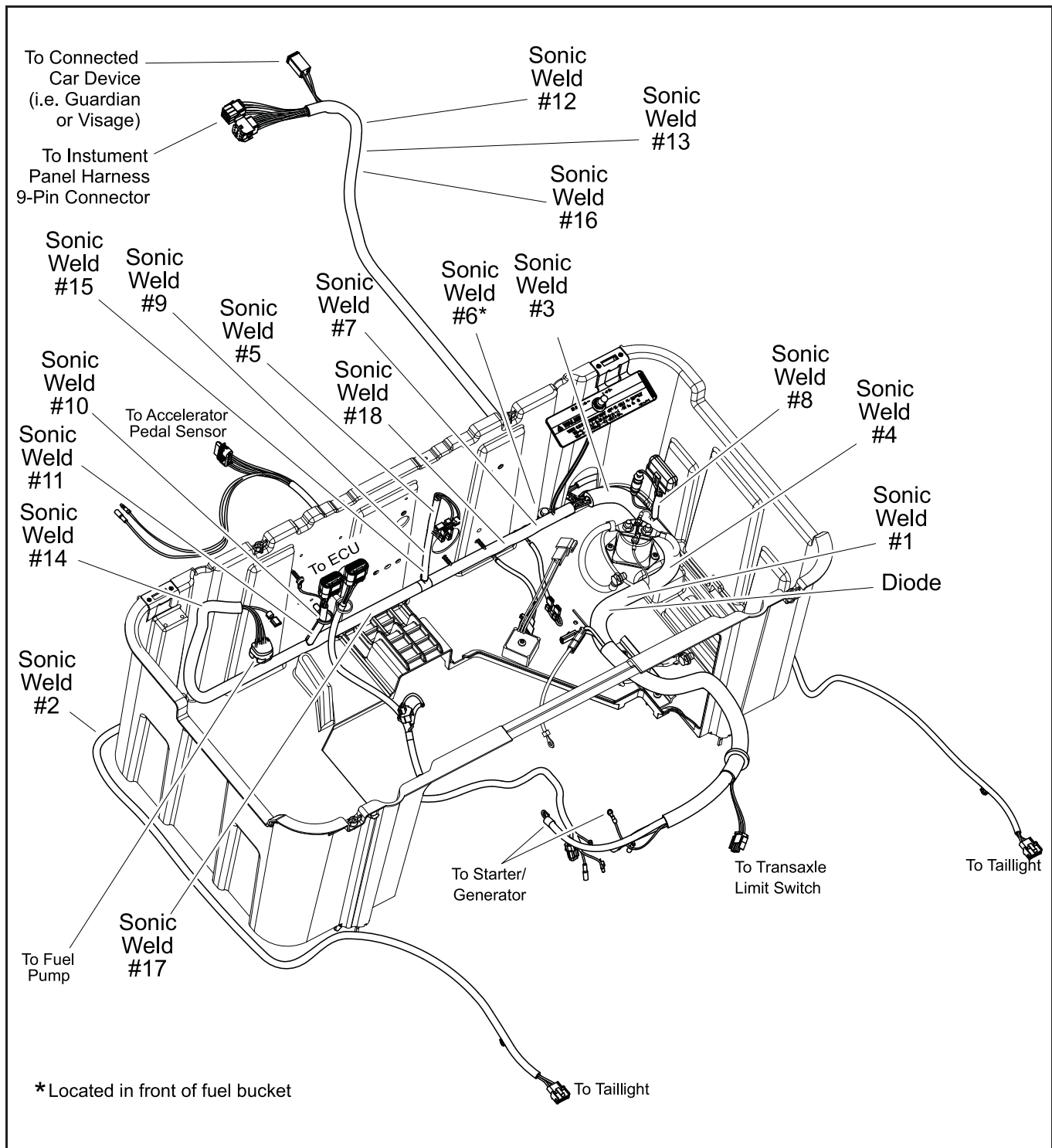


Figure 26-2 Sonic Weld and Diode Locations (Approximate) – EFI

ELECTRICAL SYSTEM

The electrical system on the gasoline vehicle is 12 volts DC with negative (–) ground to frame, and consists of the following circuits that are easily identified:

- Starter Circuit
- Generator Circuit
- Electronic Fuel Injection Circuit
- Engine Ignition Circuit
- Engine Kill Circuit
- Reverse Buzzer Circuit
- Low Oil Warning Light Circuit
- Neutral Lockout Circuit
- Fuel Pump Circuit
- Fuel Gauge and Sending Unit Circuit
- Hour Meter Circuit
- Lighting Circuit

Recognizing and understanding the function of each of these circuits will help to quickly isolate the source of an electrical problem. Use the appropriate test procedure to correct the electrical problem. **See Test Procedures on page 19-7.**

For a complete wiring diagram, see .

TEST PROCEDURES

Using the following procedures, the entire electrical system can be tested without major disassembly of the vehicle.

⚠ WARNING

- If wires are removed or replaced, make sure wiring and wire harness is properly routed and secured. Failure to properly route and secure wiring could result in vehicle malfunction, property damage, personal injury, or death.

For some tests, the electrical component box cover must be removed to gain access to the various components that are mounted inside the component box. **See following WARNING.**

⚠ WARNING

- Shorting of battery terminals can cause personal injury or death.

After test procedures are completed, be sure to replace the cover. **See following CAUTION.**

CAUTION

- Exposure to water and the elements may damage electrical components. Do not operate vehicle without the cover properly installed.

TESTING BASICS

- Battery voltage will be referenced throughout the test procedures. Battery voltage is accessed in **Test Procedure 1 – Battery on page 19-9.**
- The MAINTENANCE/OPERATE switch, in the MAINTENANCE position, grounds and kills the ignition if the FNR shifter is placed in FORWARD or REVERSE.
- The key switch powers the ECU, fuel pump, solenoid, lights, and the connected car device.
- The 2-amp fuse is powered by the key switch via the 10-amp ATM fuse and carries battery voltage to the connected car device.
- The term “back-probe” refers to probing the side of a connector that the wire enters. This is usually done when the connector must remain connected to a device. An alternative method is to use an insulation-piercing probe. **See following CAUTION.**

CAUTION

- Be careful not to damage the wire or terminal when back-probing.
- When testing voltage, the battery must remain connected.
- When testing voltage, unless specifically directed to do otherwise in a procedure, connect the black (–) probe of the multimeter to chassis ground.
- When testing resistance or continuity, turn off power to the circuit being measured and discharge any capacitor(s). The presence of voltage can cause inaccurate readings.

Index of Test Procedures

1 – Battery

- 2 – Fuses
- 3 – Ground Cables
- 4 – EFI System (ECU and Sensors)
- 5 – Key Switch (Start Circuit)
- 6 – Key Switch (Engine Kill Circuit)
- 7 – Throttle Position Sensor (TPS)
- 8 – Solenoid
- 9 – Maintenance/Operate Switch – Pedal-Start Vehicles
- 10 – Neutral Lockout Limit Switch – Pedal-Start Vehicles Only
- 11 – Starter/Generator (Generator Function)
- 12 – Starter/Generator (Starter Function)
- 13 – Voltage Regulator
- 14 – Ignition Spark
- 15 – Ignition Coil
- 16 – Reverse Buzzer and Reverse Buzzer Limit Switch
- 17 – Low Oil Warning Light (LED)
- 18 – Oil Level Sensor
- 19 – Battery Test (Under Load)
- 20 – Fuel Pump
- 21 – Fuel Level Sending Unit
- 22 – Fuel Gauge
- 23 – Hour Meter
- 24 – 4-Pin Connector (for Connected Car Device)

TEST PROCEDURE 1 – Battery

See General Warnings on page 1-2.

DANGER

- Due to the danger of an exploding battery, wear a full face shield and rubber gloves when working near a battery.
- Battery – Explosive gases! Do not smoke. Keep sparks and flames away from the vehicle and service area. Ventilate when charging or operating vehicle in an enclosed area. Wear a full face shield and rubber gloves when working on or near batteries.
- Battery – Poison! Contains acid! Causes severe burns. Avoid contact with skin, eyes, or clothing. Antidotes:
 - External: Flush with water. Call a physician immediately.
 - Internal: Drink large quantities of milk or water. Follow with milk of magnesia or vegetable oil. Call a physician immediately.
 - Eyes: Flush with water for 15 minutes. Call a physician immediately.

NOTE: The battery must be properly maintained and fully charged in order to perform the following test procedures. Battery maintenance procedures, including watering information and allowable mineral content, can be found in section **Kohler ECH440 - Electrical Components on page 20-1** of this manual. **See Battery on page 20-1.**

1. Place the Forward/Reverse handle in the NEUTRAL position and the neutral lockout switch in the MAINTENANCE position. Chock the wheels.
2. Check for loose or corroded battery terminal connections. Remove the negative (–) cable first and clean, tighten, and replace connections as necessary.

Voltage Test

1. Take a voltage reading with a multimeter set to 20 VDC by placing the red (+) probe on the positive (+) battery post and the black (–) probe on the negative (–) battery post. If it shows less than 12.4 volts, recharge the battery. If battery voltage is greater than 12.4 volts, the problem is not with the battery. If the battery does not reach 12.4 volts after charging, replace the battery. **See following NOTE.**

NOTE: Open circuit voltage should be at least 12.4 volts.

Load Test

1. Connect a 160-ampere load tester to the battery posts.
2. Turn the switch on the load tester to the ON position.
3. Read the battery voltage after the load tester has been turned ON for 15 seconds. Compare the battery's voltage reading with the following table. Make sure you have the correct ambient temperature.

| IF TEMPERATURE IS | MINIMUM CRANKING VOLTAGE |
|-------------------------|--------------------------|
| 70 °F (20 °C and above) | 9.6 V |
| 60 °F (16 °C) | 9.5 V |
| 50 °F (10 °C) | 9.4 V |
| 40 °F (4 °C) | 9.3 V |
| 30 °F (-1 °C) | 9.1 V |
| 20 °F (-7 °C) | 8.9 V |
| 10 °F (-12 °C) | 8.7 V |
| 0 °F (-18 °C) | 8.5 V |

4. If the battery is found to be good, or if the electrical problem continues after the battery has been replaced with a good one, test the electrical circuits.

TEST PROCEDURE 2 – Fuses

See General Warnings on page 1-2.

⚠ WARNING

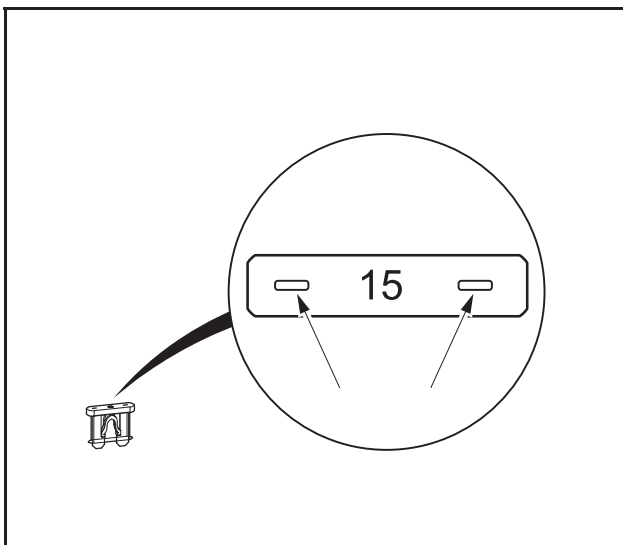
- Failure to use properly rated fuse can result in a fire hazard.

NOTE: This vehicle uses three ATM-style blade fuses. A single ABC-style glass fuse is used for the Guardian/Visage 4-pin connector that is labeled "V3 circuit" on the harness.

This is a voltage test. It can be performed relatively easily on ATM-style fuses. A voltage test can be performed on the ABC-style glass fuse if insulation-piercing probes are used. Otherwise, the ABC-style will have to be removed to visually inspect or check using a continuity test.

ATM-style blade fuses are located on the main wire harness in front of the battery.

The ABC-style glass fuse is located on the main wire harness adjacent to the ATM-fuse holder.



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Figure 26-3 Testing ATM-style Blade Fuse

1. If necessary, see Testing Basics on page 19-7.
2. Access the fuse but do not remove it.
3. **20-amp and 10-amp ATM Fuses Only:** With the battery and solenoid connected:
 - 3.1. Probe the two, small metal contacts on the top of the fuse (**Figure 26-3, Page 26-16**).
 - 3.2. Each contact should show battery voltage.
 - 3.3. If only one side shows battery voltage, replace fuse.
 - 3.4. If neither side of a fuse shows battery voltage, inspect the following locations:
 - Check condition and connection of large red wires at solenoid.
 - Check sonic weld_8 in main wire harness.

4. **5-amp ATM Fuse Only:** With the key switch in the ON position:
 - 4.1. Probe the two, small metal contacts on the top of the fuse (**Figure 26-3, Page 26-16**).
 - 4.2. Each contact should show battery voltage.
 - 4.3. If only one side shows battery voltage, replace fuse.
 - 4.4. If neither side of a fuse shows battery voltage, inspect the following locations:
 - Check the 10-amp fuse.
 - Check the key switch.
 - Check sonic weld_3 in main wire harness.
5. **2-amp ABC Glass Fuse Only:** With the key switch in the ON position:
 - 5.1. Probe the wire on each side of the fuse with insulation-piercing probes.
 - 5.2. Each probe should show battery voltage.
 - 5.3. If only one side shows battery voltage, replace fuse.
 - 5.4. If neither side of a fuse shows battery voltage, inspect the following locations:
 - Check the 10-amp fuse.
 - Check the key switch.
 - Check sonic weld_3 in main wire harness.

TEST PROCEDURE 3 – Ground Cables

See General Warnings on page 1-2.

NOTE: This is a continuity test for the main ground wire(s) of the vehicle. An additional ground wire is located on top of the fuel tank.

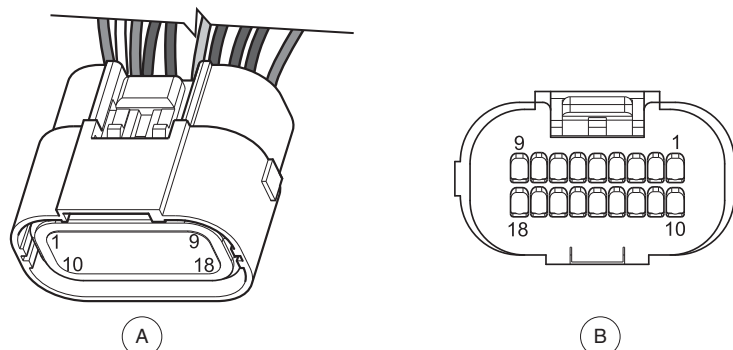
1. If necessary, see Testing Basics on page 19-7.
2. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
3. Check the following wires and cables for clean, tight connections and continuity:
 - Check the starter/generator ground cable (black wire) from A1 terminal to chassis or engine.
 - Check the engine ground cable from engine block to negative (-) main harness lead disconnected from battery.
 - Check the chassis ground cable from frame rail to negative (-) main harness lead disconnected from battery.
 - Disconnect voltage regulator from main harness. Check from black wire in 3-pin connector to negative (-) main harness lead disconnected from battery. This will test sonic weld _18 and sonic weld _1 in the main wire harness.
4. The reading should be continuity. If the reading is incorrect, clean and tighten cable connections. If the connections are good and the reading is incorrect, repair or replace the wire or cable.

TEST PROCEDURE 4 – EFI System (ECU and Sensors)

See General Warnings on page 1-2.

WARNING

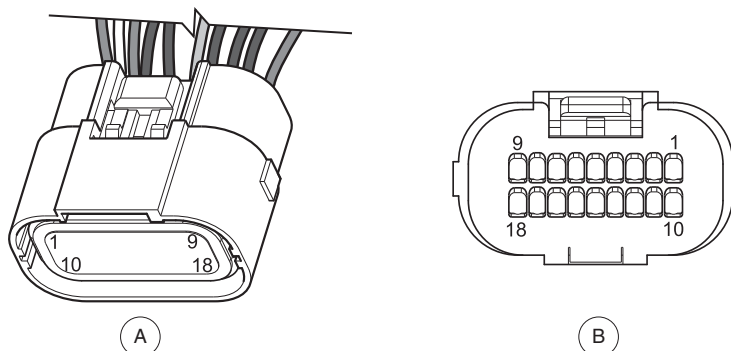
- This procedure involves testing voltage, resistance and continuity. If necessary, see Testing Basics on page 19-7.



18-PIN CONNECTOR (GRAY AND BLACK): A. ECU SIDE OF CONNECTOR B. WIRE ENTRY SIDE OF CONNECTOR

| PIN I.D. | CONNECTOR COLOR | FUNCTION | TEST TYPE & PROBE BETWEEN LOCATIONS | TEST RESULT | CONDITION |
|----------|-----------------|---|---|--|----------------------------------|
| 1 | Gray | Fuel Injector Control | Resistance: ECU Gray Pin 1 (Black/White) and ECU Gray Pin 10 (Red/White) | Approx. 12 ohms | Key OFF or ON |
| 6 | Gray | Engine Temperature Sensor Input | Resistance: ECU Gray Pin 6 (Orange/Blue) and ECU Gray Pin 15 (Black/Blue) | Approx. 11.5 kOhms @ 70 °F (21 °C) Resistance decreases as temperature rises. | Key OFF |
| 9 | Gray | Ignition Coil Input | Resistance: ECU Gray Pin 9 (White) and Ground | Approx. 10.1 kOhms | Key OFF |
| 10 | Gray | Fuel Injector Positive (+) Voltage from ECU | Voltage: ECU Gray Pin 10 (Red/White) and Ground | Battery Voltage | Plug connected to ECU and Key ON |
| 13 | Gray | MAP Sensor Input | Voltage: ECU Gray Pin 13 (Green/Yellow) and Ground | Approx. 3.9 volts @ sea level & engine OFF / 3.0 volts engine running. Voltage decreases as pressure decreases. | Key ON and engine running |
| 15 | Gray | Engine Temperature Sensor Ground | Continuity: ECU Gray Pin 15 (Black/Blue) and Ground | Meter should beep | Key OFF |
| 16 | Gray | MAP Sensor Reference Voltage (+5) | Voltage: ECU Gray Pin 16 (Red/Yellow) and ECU Gray Pin 17 (Black/Yellow) | Approx. 5 volts | Key ON |
| 17 | Gray | MAP Sensor Ground | Continuity: ECU Gray Pin 17 (Black/Yellow) and Ground Voltage: ECU Gray Pin 17 (Black/Yellow) and Battery (+) Terminal | Meter should beep –Battery Voltage | Key OFF Key OFF |
| 1 | Black | Fuel Pump Input | Voltage: ECU Black Pin 1 (Black/White) and ECU Black Pin 10 (Black) | Battery Voltage (after pump stops running) | Key ON |

TABLE CONTINUED ON NEXT PAGE



18-PIN CONNECTOR (GRAY AND BLACK): A. ECU SIDE OF CONNECTOR B. WIRE ENTRY SIDE OF CONNECTOR

| PIN I.D. | CONNECTOR COLOR | FUNCTION | TEST TYPE & PROBE BETWEEN LOCATIONS | TEST RESULT | CONDITION |
|----------|-----------------|----------------------------------|--|---|-------------------|
| 3 | Black | Ignition OFF Input | Continuity: ECU Black Pin 3 (White/Black) and Ground | Meter should beep | Key OFF |
| | | | | Meter should NOT beep | Key ON |
| 7 | Black | Low Oil Sensor Input | Resistance: ECU Black Pin 7 (Yellow) and Ground | Approx. 2.3 kOhms | Key OFF |
| 8 | Black | Connected Car Link | Voltage: ECU Black Pin 8 (Blue) and Ground | 11.8 volts | Key ON |
| 9 | Black | B+ Input | Voltage: ECU Black Pin 9 (Red) and ECU Black Pin 10 (Black) | Battery Voltage | Key ON |
| 10 | Black | Ground for ECU Power | Continuity: ECU Black Pin 10 (Black) and Ground | Meter should beep | Key OFF |
| | | | Voltage: ECU Black Pin 10 (Black) and Battery (+) Terminal | –Battery Voltage | Key OFF |
| 11 | Black | Diagnosis (low oil) Lamp Control | Voltage: ECU Black Pin 11 (Yellow) and Ground | Less than 1 Volt initially. 7 to 8 volts after lamp is OFF. | Key ON |
| 12 | Black | Foot Input | Continuity: ECU Black Pin 12 (White/Black) and Black Pin 18 (Black) | | Key OFF with: |
| | | | | Meter should beep | Accel. Pedal UP |
| | | | | Infinity | Accel. Pedal DOWN |
| 18 | Black | Ground for ECU Housing | Continuity: ECU Black Pin 18 (Black) and Ground | Meter should beep | Key OFF |
| | | | Voltage: ECU Black Pin 18 (Black) and Battery (+) Terminal | –Battery Voltage | Key OFF |

TEST PROCEDURE 5 – Key Switch (Start Circuit)

See General Warnings on page 1-2.

NOTE: This is a voltage test.

The key switch provides power and KEY INPUT to the ECU.

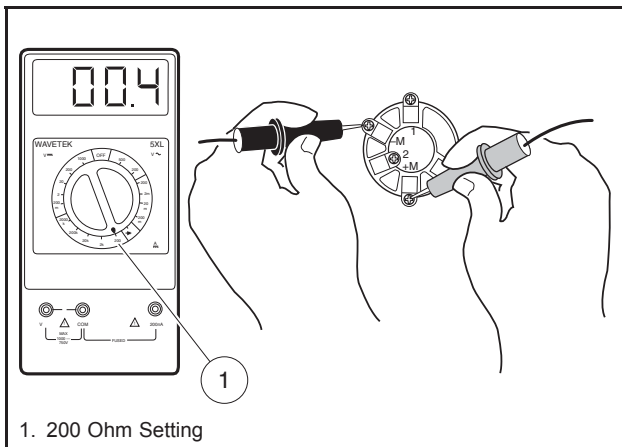
1. If necessary, see Testing Basics on page 19-7.
2. Remove instrument panel to access the back of the key switch but do not disconnect wires. **See Instrument Panel Removal, Section 4, Page 4-12.**
3. With the key switch in the OFF position:
 - The red wire should show battery voltage coming to the switch.
 - The blue wire should show zero (0) volts. If it shows battery voltage, the switch has failed CLOSED and must be replaced.
4. With the key switch in the ON position:
 - The blue wire should show battery voltage passing through the key switch to a sonic weld in the instrument panel harness, the 9-pin connector, sonic weld_3, the 5-amp fuse, the solenoid, and the 4-pin connected car plug. If it does not show battery voltage, the switch has failed OPEN and must be replaced.

TEST PROCEDURE 6 – Key Switch (Engine Kill Circuit)

See General Warnings on page 1-2.

NOTE: This is a continuity test.

1. If necessary, see Testing Basics on page 19-7.
2. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
3. Remove the instrument panel. **See Instrument Panel Removal, Section 4, Page 4-12.**
4. Disconnect wires from the (+M) and (–M) terminals of the key switch (**Figure 19-3, Page 19-12**).
5. Place the red (+) probe on the (+M) terminal and the black (–) probe on the (–M) terminal. With the key switch OFF, the reading should be continuity. With the key switch ON, the reading should be no continuity. If either reading is incorrect, replace the key switch.
6. Connect wires to the key switch. Make sure wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
7. Install dash panel in reverse order of removal.



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Figure 26-4 Key Switch Test – Engine Kill Circuit

TEST PROCEDURE 7 – Throttle Position Sensor (TPS)

The throttle position sensor performs the function of two limit switches: the accelerator pedal limit switch and the kill limit switch. This sensor is sealed and is not to be repaired or replaced. If sensor is determined to need replacing through test procedures found in this manual, the accelerator pedal assembly must be replaced. **See Accelerator Pedal on page 5-10.** The sensor is joined to the main wire harness through a six-pin connector. Tests for the sensor are found in the following two procedures.

Accelerator Pedal Limit Switch Function

See General Warnings on page 1-2.

The green and orange wires connect to the accelerator pedal limit switch function of the throttle position sensor. This is the normally open (NO) portion of the circuit used to energize the starter solenoid.

NOTE: Keep the battery connected while performing this test procedure.

1. Place the neutral lockout switch in the MAINTENANCE position, put the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Disconnect the spark plug wire from the spark plug.
3. Disconnect gray 18-pin connector from ECU.
4. With battery connected and using a multimeter set to the diode test function (c), attach the red (+) lead to the orange wire at the starter solenoid and the black (-) lead to the green wire at the limit switch located on the Forward/Reverse shifter assembly. **See following NOTE.**

NOTE: It may be necessary to partially pull the green wire from the switch terminal to attach the black lead.

5. Turn the key switch to the ON position. With accelerator pedal at rest in the fully raised position, the meter should indicate an over limit (no continuity) condition.
6. Press the accelerator to engage the starter and engine. With accelerator pedal pressed, the meter should indicate approximately 1.0 volt. If either reading is incorrect, replace the accelerator pedal assembly. **See Accelerator Pedal on page 5-10.**

Kill Limit Switch Function

See General Warnings on page 1-2.

The black and white/black wires connect to the kill limit switch function of the throttle position sensor. This is the normally closed (NC) portion of the circuit used to ground the ignition and shut the engine off when the pedal is released.

NOTE: *Keep the battery connected while performing this test procedure.*

1. Place the neutral lockout switch in the MAINTENANCE position, put the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Disconnect gray 18-pin connector from ECU.
3. Disconnect the spark plug wire from the spark plug.
4. With battery connected and using a multimeter set to the diode test function (Ꞇ), attach the red (+) lead to the negative (-) battery terminal and the black (-) lead to the white/black wire at the limit switch located on the Forward/Reverse shifter assembly. **See following NOTE.**

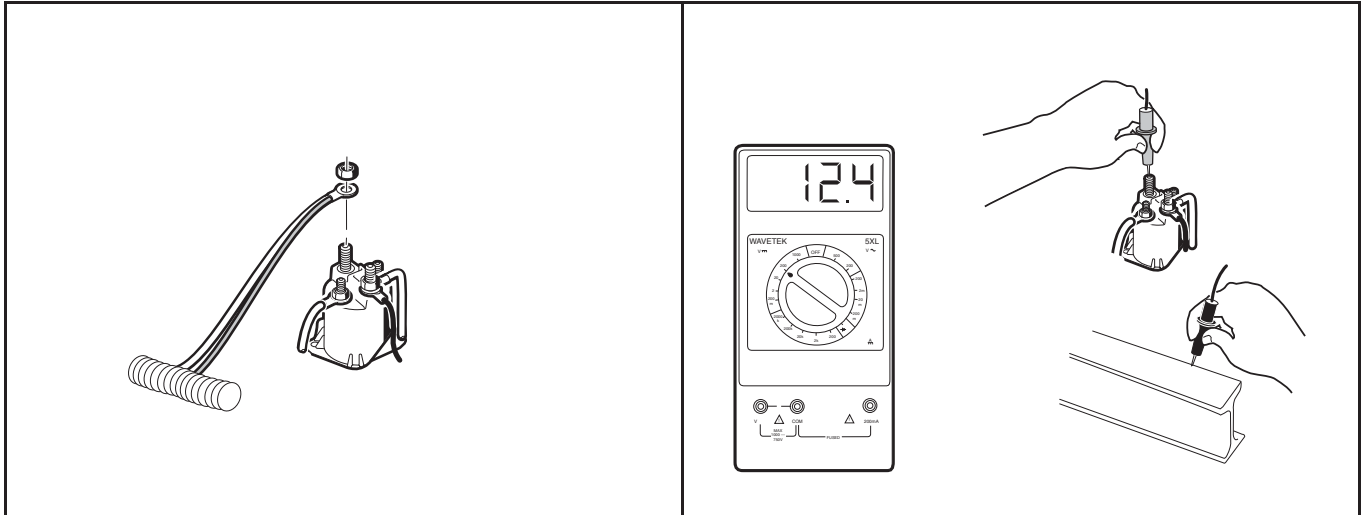
NOTE: *It may be necessary to partially pull the white/black wire from the switch terminal to attach the black lead.*

5. Turn the key switch to the ON position. With accelerator pedal at rest in the fully raised position, the meter should indicate approximately 1.0 volt.
6. Press the accelerator to engage the starter and engine. With accelerator pedal pressed, the meter should indicate an over limit (no continuity) condition. If either reading is incorrect, replace the accelerator pedal assembly. **See Accelerator Pedal on page 5-10.**

TEST PROCEDURE 8 – Solenoid

See General Warnings on page 1-2.

NOTE: This is a resistance and voltage test.



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Figure 26-5 Solenoid Wire Removal

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Figure 26-6 Solenoid Ground Test

1. If necessary, see Testing Basics on page 19-7.
2. Ensure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
3. **Coil Side:** Check resistance across the small posts of the solenoid. The reading should be 14 to 16 ohms. If the reading is not within limits, replace the solenoid.
4. **Contact Side:** Remove the heavy-gauge white wire and 16-gauge red wire from the large post of the solenoid (**Figure 19-4, Page 19-14**). Do not allow the wires to touch the frame or other components of the vehicle. Cover the other large post.
 - 4.1. Place Forward/Reverse handle in the NEUTRAL position, neutral lockout switch in the MAINTENANCE position, and key switch in the ON position.
 - 4.2. Check voltage between the empty large post and ground (**Figure 19-5, Page 19-14**).
 - **With accelerator pedal in the UP position:** The meter should read no voltage.
 - **With accelerator pedal pressed:** The solenoid should click and the meter should read battery voltage.
 - 4.3. If the readings are incorrect, replace solenoid. **See Solenoid Removal, Section 20, Page 20-19.**

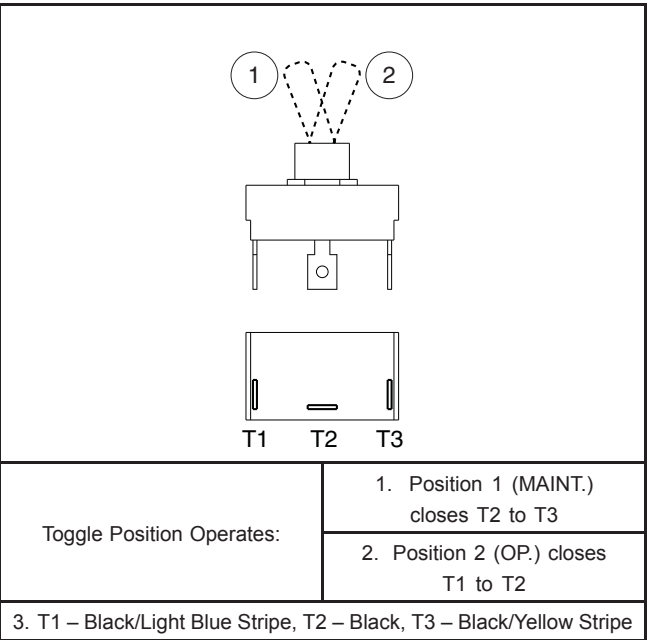
TEST PROCEDURE 9 – Maintenance/Operate Switch – Pedal-Start Vehicles

See General Warnings on page 1-2.

NOTE: This is a continuity test.

The Maintenance/Operate Switch is also known as the Neutral Lockout Switch.

1. If necessary, see Testing Basics on page 19-7.
2. Remove wires from switch (**Figure 19-6, Page 19-15**).
3. With switch in position 1 (MAINTENANCE):
 - 3.1. Check for no continuity between terminals T1 and T2.
 - 3.2. Check for continuity between terminals T2 and T3.
4. With switch in position 2 (OPERATE):
 - 4.1. Check for no continuity between terminals T2 and T3.
 - 4.2. Check for continuity between terminals T1 and T2.



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Figure 26-7 Maintenance/Operate Switch Test – for Pedal-Start Vehicles

5. If switch:
 - 5.1. does not work as stated in previous steps, replace switch.
 - 5.2. does work as stated and the MAINTENANCE/OPERATE modes still do not work:
 - Check the limit switches.
 - Check continuity of the wires involved.

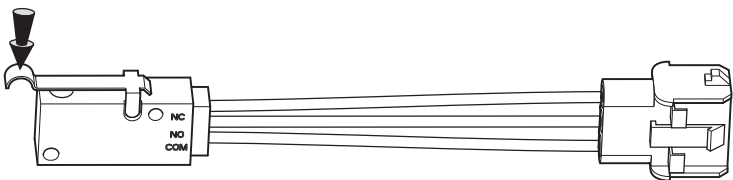
TEST PROCEDURE 10 – Neutral Lockout Limit Switch – Pedal-Start Vehicles Only

See General Warnings on page 1-2.

NOTE: This is a continuity test.

This switch is located on the transaxle. A black/light blue wire, a red wire, and a blue wire are connected to this limit switch with a 3-pin connector.

1. If necessary, see Testing Basics on page 19-7.
2. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
3. At transaxle, disconnect neutral lockout limit switch three-wire lead from main wire harness.
4. Check to be sure the cam lobe on the shift lever is pressing the neutral lockout limit switch as the Forward/Reverse shifter is being shifted. The limit switch should make an audible click as it is pressed. If it does not, check for wear on the cam lobe and replace shift lever if necessary.
5. Check the following terminals for no continuity with the lever released and continuity with the lever engaged (**Figure 19-7, Page 19-16**):

|  | |
|---|---|
| PROBE BETWEEN LOCATIONS | TEST RESULT |
| Between terminal 1 "COM" (black/light blue wire) and terminal 2 "NO" (red wire) | With lever released: No continuity |
| | With lever pressed: Continuity |
| Between terminal 1 "COM" (black/light blue wire) and terminal 3 "NC" (blue wire) | With lever released: Continuity |
| | With lever pressed: No continuity |

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Figure 26-8 Neutral Lockout Limit Switch Test

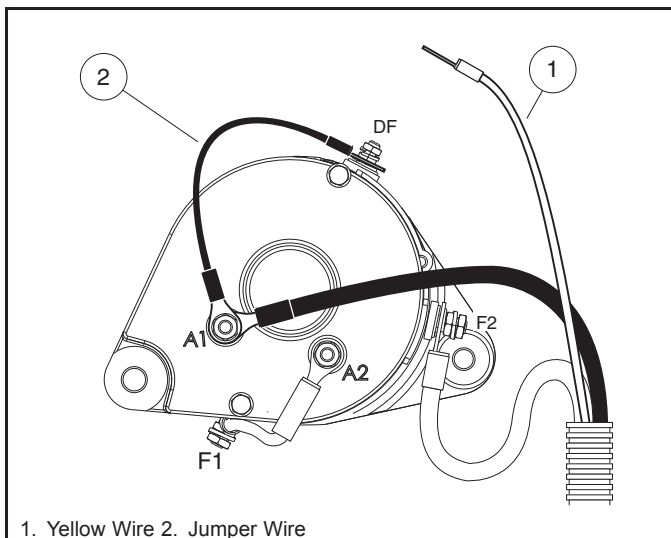
6. If switch does not work as stated in previous step, replace switch. **See Transaxle Limit Switch Removal, Section 20, Page 20-27.**

TEST PROCEDURE 11 – Starter/Generator (Generator Function)

See General Warnings on page 1-2.

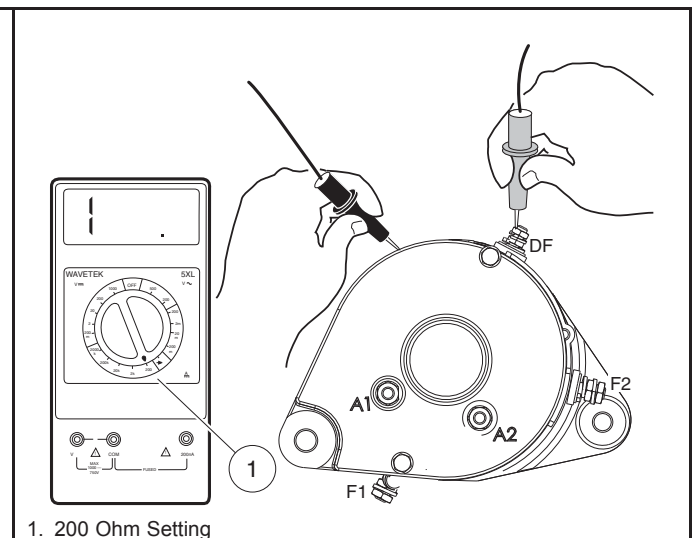
NOTE: This is a voltage test.

1. If necessary, see Testing Basics on page 19-7.
2. Place the Forward/Reverse handle in the NEUTRAL position and the neutral lockout switch in the MAINTENANCE position. Chock the wheels.
3. Ensure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
4. Disconnect yellow wire from DF terminal on starter/generator. Cover terminal on yellow wire to make sure it will not short to ground. Then, using a jumper wire, ground DF terminal to A1 terminal (**Figure 26-9, Page 26-27**).
5. Using a multimeter set to 20 volts DC, place the red (+) probe on the positive (+) post of the battery, and place the black (–) probe on the negative (–) post. Start the engine and run it at full governed speed. The reading should show the voltage rising on the meter. If the voltage rises above 15.3 volts DC, test the voltage regulator. **See Voltage Regulator on page 19-20.** If the voltage does not rise, a tear-down inspection of the starter/generator will be necessary. **See Starter/Generator Removal on page 20-4.**
6. Remove jumper wire.
7. Reconnect yellow wire to DF terminal on starter/generator.



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Figure 26-9 Jumper Wire Ground – DF to A1



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Figure 26-10 Check Starter Terminal Continuity

TEST PROCEDURE 12 – Starter/Generator (Starter Function)

See General Warnings on page 1-2.

NOTE: Observe the following before testing the starter/generator:

- This is only testing continuity.
- Tag the starter/generator wires for identification before disconnecting.
- Remove starter/generator wire from one of the “A” terminals and one of the “F” terminals if testing while starter/generator is in vehicle.

- When disconnecting wires from starter/generator terminals, use a second wrench on the lower nut of the terminal post to hold post steady.
- Scrape a small amount of paint from starter/generator housing (ground) and use this location when testing motor terminals to electrical ground.

| MOTOR TERMINALS | CONTINUITY TEST RESULT |
|------------------------------|---------------------------|
| A1 to A2 F1 to F2 | Continuity |
| A1 to F1 A1 to F2 | No Continuity |
| A2 to F1 A2 to F2 | No Continuity |
| A1 to Ground A2 to Ground | No Continuity |
| F1 to Ground F2 to Ground | No Continuity |

1. If necessary, see Testing Basics on page 19-7.
2. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
3. Disconnect the wires from all the terminals on the starter/generator. Then place the black (–) probe of a multimeter, set to 200 ohms, on the starter/generator housing (scratch through the finish to ensure a good ground). While holding the black (–) probe against the housing, place the red (+) probe (one at a time) on the A1, A2, F1, F2 and DF terminals respectively (**Figure 19-9, Page 19-19**). The readings should be no continuity. If the readings are incorrect, the starter/generator will need to be removed from the vehicle and disassembled by a qualified technician. **See Starter/Generator Removal on page 20-4.**
 - An incorrect reading from the A1 or A2 terminal indicates three possible problems: 1) a grounded A1 or A2 terminal, 2) a grounded wire in the brush area, or 3) a grounded armature/commutator.
 - If the F1 or F2 reading is incorrect, it indicates a possible grounded F1 or F2 terminal or a grounded field coil.
 - If the DF reading is incorrect, it indicates a possible grounded DF terminal or a grounded field coil.
4. Using a multimeter set to 200 ohms, place the red (+) probe on the A1 terminal and the black (–) probe on the A2 terminal. The reading should be continuity. If the reading is incorrect, a possible open or poor contact in a brush assembly and/or open armature windings may be the cause. The starter/generator will need to be removed from the vehicle and disassembled by a qualified technician. **See Starter/Generator Removal on page 20-4.**
5. With the wires still disconnected, using a multimeter set on 200 ohms, place the red (+) probe on the F1 terminal and the black (–) probe on the F2 terminal. The reading should be between approximately 0.1 and 0.3 ohms. If the reading is incorrect, a possible open field coil or bad connections at terminals may be the cause. The starter/generator will need to be removed from the vehicle and disassembled by a qualified technician. **See Starter/Generator Removal on page 20-4.**
6. With the wires still disconnected, using a multimeter set to 200 ohms, place the red (+) probe on the DF terminal and the black (–) probe on the F1 terminal. The reading should be between 4.5 and 5.5 ohms. If the reading is incorrect, a possible grounded DF terminal and/or grounded field coil may be the cause. The starter/generator will need to be removed from the vehicle and disassembled by a qualified technician. **See Starter/Generator Removal on page 20-4.**

Ensure that wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.

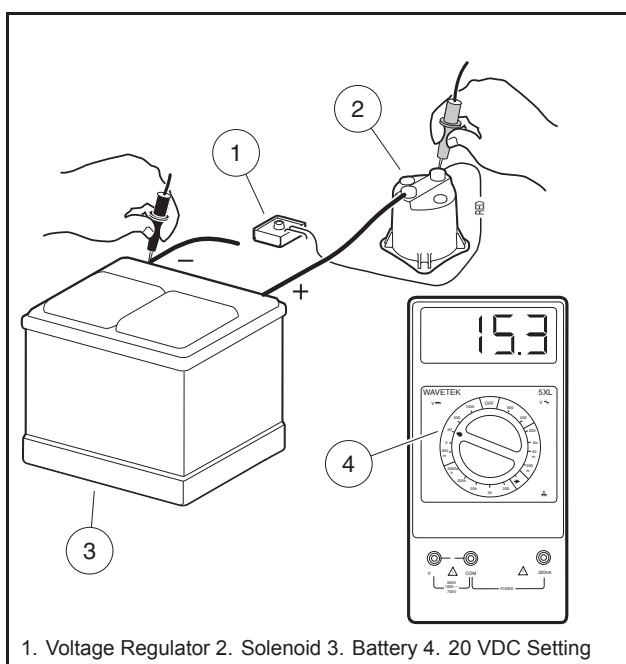
TEST PROCEDURE 13 – Voltage Regulator

See General Warnings on page 1-2.

NOTE: This is a voltage test.

Keep the battery connected while performing this test procedure.

1. If necessary, see Testing Basics on page 19-7.
2. Place the Forward/Reverse handle in the NEUTRAL position and the neutral lockout switch in the MAINTENANCE position. Chock the wheels.
3. Ensure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary.
4. Check the engine RPM setting to ensure that it is adjusted correctly. **See Engine RPM Adjustment on page 22-9.**
5. With the battery in good condition and fully charged, run the engine for several minutes to bring the voltage regulator to operating temperature.
6. Turn the key switch to the OFF position, killing the engine. Using a multimeter set to 20 volts DC, place the red (+) probe on the large post of the solenoid with the red wire from the voltage regulator attached. Place the black (–) probe on the negative (–) battery post (**Figure 19-10, Page 19-20**). Turn the key switch to the ON position. Press the accelerator to start the engine and run it at full governed speed. If the reading is between 14.7 and 15.3 volts, the regulator is good. If the reading is lower than 14.7 volts but rising steadily, check battery condition. If the reading is lower than 14.7 volts and not rising, and the starter/generator is good; or if the reading is over 15.3 volts and continues to rise, replace voltage regulator. **See Voltage Regulator Removal, Section 20, Page 20-21.**



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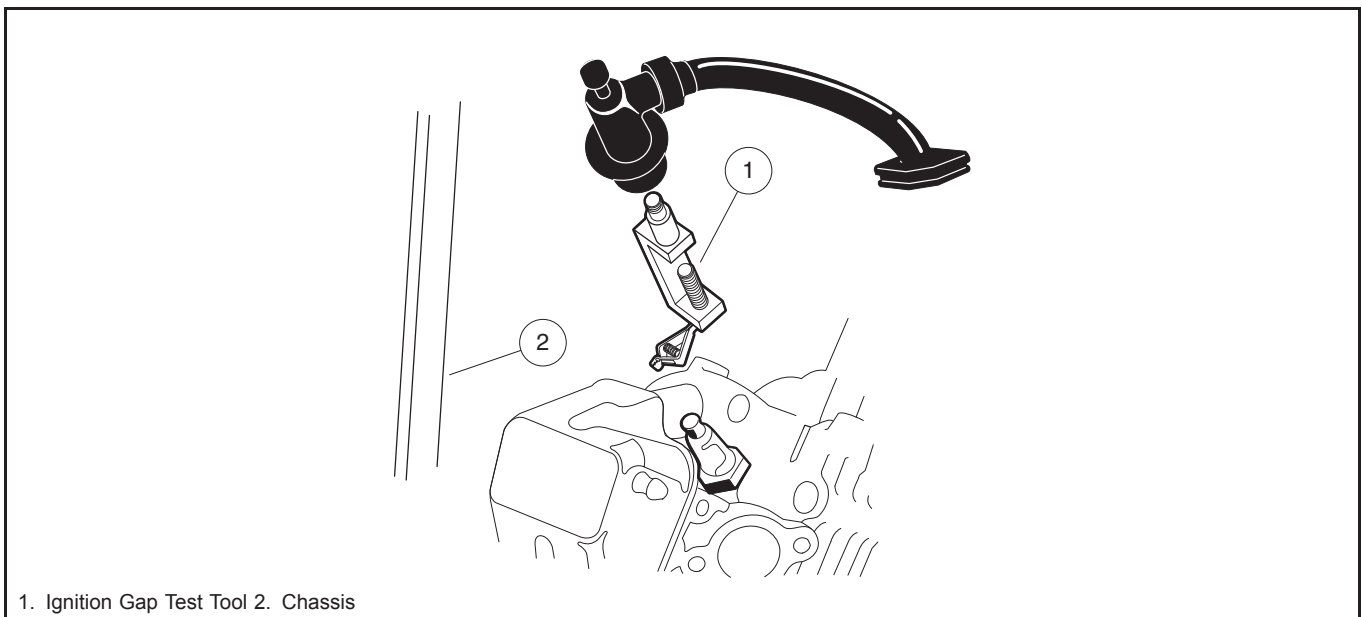
Figure 26-11 Voltage Regulator Test

TEST PROCEDURE 14 – Ignition Spark

See General Warnings on page 1-2.

NOTE: Keep the battery connected while performing this test procedure.

1. If necessary, see Testing Basics on page 19-7.
2. Place the Forward/Reverse handle in the NEUTRAL position and the neutral lockout switch in the MAINTENANCE position. Chock the wheels.
3. Remove the plug wire from the spark plug. Using an ignition spark gap test tool (Thexton 404® or equivalent), check for correct spark (**Figure 19-11, Page 19-21**).
- 3.1. Adjust the tester probes to approximately 18,000 volts (18 kV) setting (SE – *Small Engine Setting* on the Thexton 404 tool). Connect the tester to the spark plug wire, and connect the alligator clip to a solid engine ground.
- 3.2. Start the engine. There should be a strong blue spark between the probes of the spark gap tester. If there is no spark, or if the spark is a faint yellow or red color, test components of the ignition circuit. **See Ignition Coil on page 26-31.**
4. If the spark gap tester tool indicates a strong blue spark, it is possible the spark plug has failed internally. Check the spark plug gap. The gap should be set at 0.024 to 0.028 in. (0.6 to 0.7 mm). If the gap is correct, replace the spark plug with a new part and test the engine for proper operation.



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Figure 26-12 Ignition Spark Test

TEST PROCEDURE 15 – Ignition Coil

See General Warnings on page 1-2.

NOTE: This is a resistance test.

The following test procedures will properly detect a coil that has failed in most cases; however, in rare cases, some ignition coils can fail to operate at normal (warmer) operating temperatures. If the ignition coil has tested okay in the vehicle and on the bench, but fails to operate reliably, replace the coil with a known good coil and operate the engine for several minutes to ensure that the coil functions at normal operating temperature. If the new coil functions properly, keep the new coil in the circuit.

NOTE: Resistance value ranges given in these tests reflect a tolerance of $\pm 40\%$.

Please note that these values are rough standard and it is impossible to reach an exact conclusion with the resistance reading.

1. If necessary, see Testing Basics on page 19-7.
2. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
3. At engine, access white wire in ECU wire harness that connects to ignition coil lead at back of engine.
4. Using a multimeter set to 200k ohms, measure resistance between the following locations listed in table below.

| IGNITION COIL TERMINALS | TEST RESULT |
|-------------------------------------|----------------|
| White Signal Wire to Ground | 9 to 11 kOhms |
| White Signal Wire to Spark Plug Cap | 17 to 20 kOhms |
| Spark Plug Cap to Ground | 8 to 13 kOhms |

TEST PROCEDURE 16 – Reverse Buzzer and Reverse Buzzer Limit Switch

See General Warnings on page 1-2.

NOTE: Reverse Buzzer: This is a voltage test.

Reverse Buzzer Limit Switch: This is a continuity test.

A reverse buzzer is mounted on the back side of the instrument panel. On some models, another reverse buzzer is also mounted on a bracket at the left rear of the vehicle. The reverse buzzer is powered by the 10-amp ATM fuse located on the main wire harness in front of the engine.

The reverse buzzer limit switch is located on the Forward/Reverse shifter. Red/white and orange wires are connected to it.

1. If necessary, see Testing Basics on page 19-7.
2. To test the front reverse buzzer, remove instrument panel. **See Instrument Panel Removal, Section 4, Page 4-12.**
3. Check for proper wiring and tight connections.
4. Check that battery voltage is present in the red/white wire at buzzer.
5. Place the Forward/Reverse handle in the REVERSE position. The buzzer should sound. If not, check limit switch in the next steps.
6. Disconnect black wire from buzzer.
7. With Forward/Reverse handle still in the REVERSE position, there should be continuity between the black wire and ground. With Forward/Reverse handle still in the FORWARD position, there should be no continuity. If either reading is incorrect, replace limit switch. **See Multi-Purpose Buzzer Limit Switch Removal, Section 20, Page 20-24.**
8. If limit switch is operating properly, replace buzzer. **See Multi-Purpose Buzzer Removal, Section 20, Page 20-35.**

TEST PROCEDURE 17 – Low Oil Warning Light (LED)

See General Warnings on page 1-2.

NOTE: This is a voltage test.

When the key switch is placed in the ON position, the Low Oil Warning Light will illuminate for approximately 3 seconds as a bulb check function.

1. If low oil warning light does not illuminate for approximately 3 seconds when the key switch is placed in the ON position, proceed with the steps below.
2. If necessary, see Testing Basics on page 19-7.
3. Remove the instrument panel. **See Instrument Panel Removal, Section 4, Page 4-12.**
4. Ensure that the wires are connected correctly and are tight. If they are not, rewire or tighten as necessary. **See Sonic Weld and Diode Locations on page 26-10.**
5. With key switch in ON position, test for battery voltage at yellow/white wire to low oil warning light. If no voltage, check key switch. **See Key Switch (Start Circuit) on page 19-11.**
6. If battery voltage is present, use a test lead to ground the yellow wire terminal of low oil warning light. Light should illuminate. If not, replace low oil warning light.

TEST PROCEDURE 18 – Oil Level Sensor

See General Warnings on page 1-2.

NOTE: Keep the battery connected while performing this test procedure.

This procedure requires the oil to be drained from the engine.

1. If necessary, see Testing Basics on page 19-7.
2. Place the Forward/Reverse handle in the NEUTRAL position, the neutral lockout switch in the MAINTENANCE position, turn the key switch to the OFF position, disconnect the spark plug wire, and chock the wheels.
3. Ensure that the low oil warning light and all connecting wires are functioning correctly. **See Low Oil Warning Light (LED) on page 19-23.**
4. Drain the engine oil into an approved container and properly dispose of used oil.
5. Turn the key switch ON, closing the circuit. The low oil warning light should illuminate. If the low oil warning light does not illuminate, the oil level sensor needs to be replaced. **See Oil Level Sensor Removal on page 28-12.**
6. Fill the engine with new oil before returning the vehicle to service. **See Engine Oil – Gasoline Vehicle on page 28-2.**

TEST PROCEDURE 19 – Battery Test (Under Load)

See General Warnings on page 1-2.

NOTE: Keep the battery connected while performing this test procedure.

1. If necessary, see Testing Basics on page 19-7.
2. Place the Forward/Reverse handle in the NEUTRAL position and the neutral lockout switch in the MAINTENANCE position. Chock the wheels.
3. Set a multimeter to 20 volts DC and place the red (+) probe on the F2 (white wire) terminal on the starter/generator. Place the black (–) probe on the negative (–) battery post.
4. Turn the key switch to the ON position, leave the Forward/Reverse shifter in the NEUTRAL position and press the accelerator pedal (with the accelerator pedal pressed, the battery is under load).
- 4.1. If the voltage reading is over 9.6 volts, with an electrolyte temperature of 70 °F (21 °C), check the starter/generator. **See following NOTE.**

NOTE: The voltage reading listed is for electrolyte at 70 °F (21 °C). At lower electrolyte temperatures the voltage reading will be lower.

5. If the reading is below 9.6 volts, with an electrolyte temperature of 70 °F (21 °C), check the battery. **See Battery on page 19-9.**
- 5.1. If the reading is zero, there may be no continuity across the large posts of the solenoid. **See Solenoid on page 19-14.**
6. If all of the test results are good and the voltage reading is zero, there may be a broken or damaged heavy-gauge white wire from the solenoid to the starter/generator. **See Starter/Generator (Starter Function) on page 19-18.**

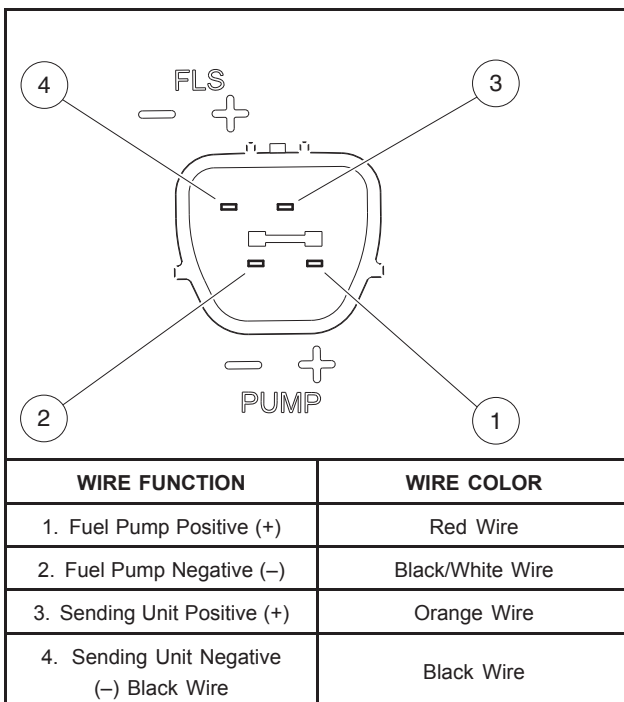
TEST PROCEDURE 20 – Fuel Pump

See General Warnings on page 1-2.

⚠ WARNING

- To avoid the possibility of fire or explosion, make sure the fuel tank cap is securely in place while performing this test procedure.

NOTE: This is a voltage and resistance test.



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Figure 26-13 Fuel Pump Module Terminals

Voltage to Pump

1. If necessary, see Testing Basics on page 19-7.
2. Disconnect the 5-pin connector from the top of the fuel pump module.
3. Check that battery voltage is present between ground and the red wire of the 5-pin connector immediately after the key switch is placed in the ON position.

NOTE: The fuel pump and low oil warning light operate for a few seconds when key switch is turned to the ON position; it stops if no engine RPM is detected by the ECU.

4. If no voltage, check key switch. **See Key Switch (Start Circuit) on page 19-11.**

Pump

1. If necessary, see Testing Basics on page 19-7.
2. Disconnect battery.
See Disconnect the Battery - Gasoline Vehicles on page 1-3.

3. Disconnect the 5-pin connector from the top of the fuel pump module.
4. Probe between pin (1) and pin (2) terminals in module (**Figure 19-14, Page 19-26**).
- 4.1. The reading should be approximately 2 to 5 ohms. If the reading indicates no resistance, the fuel pump has failed and the fuel pump module must be replaced. **See Fuel Pump Module Removal on page 22-17.**
- 4.2. If the reading is correct and the fuel pump does not function correctly, check the continuity of the red wire from the fuel pump to the red wire of the black 18-pin ECU connector. This red wire contains sonic weld 11. Leave the battery disconnected while checking continuity. Also, check the continuity of the black/white wire from the fuel pump to the black/white wire of the black 18-pin ECU connector.

TEST PROCEDURE 21 – Fuel Level Sending Unit

See General Warnings on page 1-2.

WARNING

- To avoid the possibility of fire or explosion, make sure the fuel tank cap is securely in place while performing this test procedure.

NOTE: This is a resistance test.

1. If necessary, see Testing Basics on page 19-7.
2. Disconnect battery.
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
3. Disconnect the 5-pin connector from the top of the fuel pump module.
4. Probe between pin (3) and pin (4) terminals in module (**Figure 19-14, Page 19-26**).
5. The following resistance readings (in ohms) should be obtained depending on the position of the float inside the fuel tank. The resistance reading will vary according to the exact position of the float. The chart below may be used as a guideline to determine if the fuel level sending unit is operating correctly. Make sure the float is at the surface of the fuel in the tank.

| FLOAT POSITION | RESISTANCE READING | FUEL GAUGE READINGS |
|----------------------------------|-----------------------|---------------------|
| Lower position (tank empty) | 250 ohms (± 10) | Empty |
| Center position (tank half full) | 141 ohms (± 8) | Half full |
| Upper position (tank full) | 33.3 ohms (± 6) | Full |

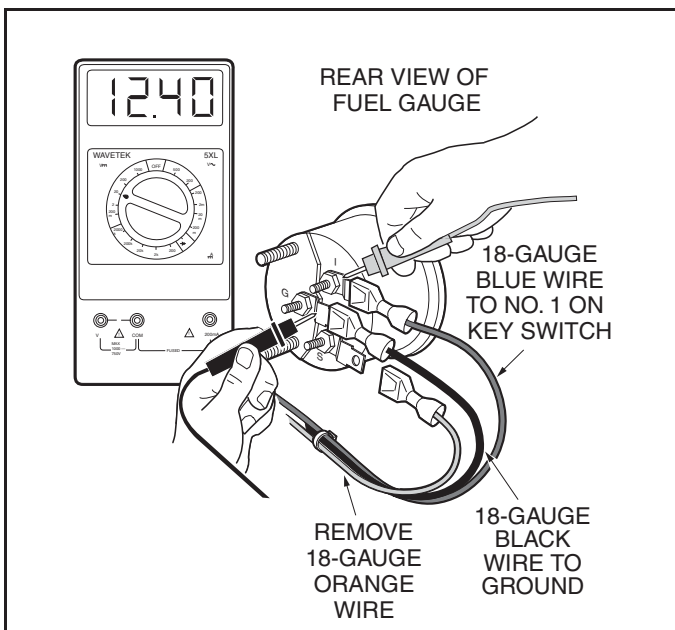
6. If the readings are within the specifications listed above, the fuel level sending unit is working properly. If the readings are incorrect, the fuel level sending unit has failed and the fuel pump module must be replaced. **See Fuel Pump Module Removal on page 22-17.**
7. If the readings are correct and the fuel gauge does not function correctly, check the continuity of the orange wire from the fuel level sending unit to the orange wire on the fuel gauge/hour meter. Leave the battery disconnected while checking continuity. Also check the continuity of the blue wire from the fuel gauge/hour meter to the blue wire on the key switch, and the black ground wires at the fuel level sending unit and at the fuel gauge/hour meter.
8. If the readings are correct according to the position of the float, but give an incorrect reading on the fuel gauge, test the fuel gauge. **See Fuel Gauge on page 26-36.**

TEST PROCEDURE 22 – Fuel Gauge

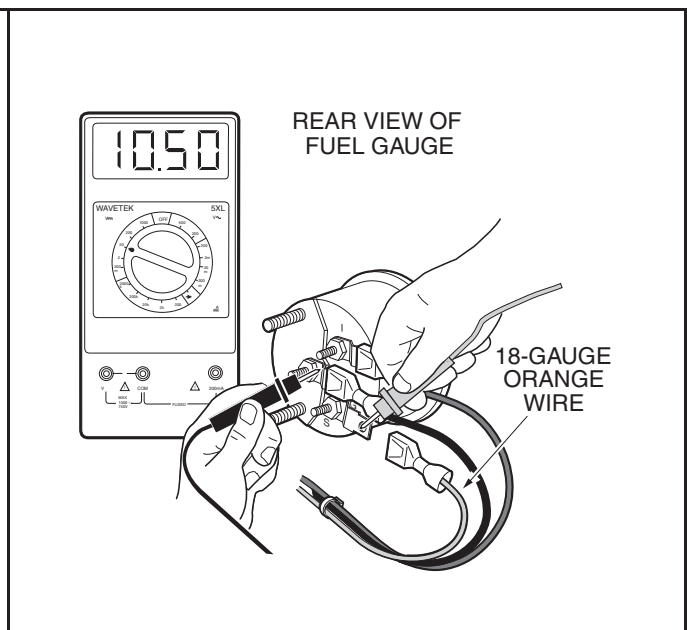
See General Warnings on page 1-2.

NOTE: This is a voltage test.

1. If necessary, see Testing Basics on page 19-7.
2. Turn the key switch OFF and remove the key. Place the Forward/Reverse handle in the NEUTRAL position. Chock the wheels.
3. Remove the instrument panel to gain access to the back of the fuel gauge. **See Key Switch Removal on page 20-32.**
4. Disconnect the orange wire from the fuel gauge.
5. Set a multimeter to 20 volts DC and place the red (+) probe of the multimeter on the blue wire terminal of the fuel gauge. Place the black (–) probe on the black wire terminal of the fuel gauge (**Figure 26-14, Page 26-36**).
6. Turn the key switch ON. The voltage reading should be battery voltage. If not, check the continuity of the blue and black wires (**Figure 26-14, Page 26-36**).
7. The orange wire should remain disconnected for this step. With the black probe still on the black wire terminal of the fuel gauge, place the red (+) probe of the multimeter on the terminal for the orange wire. The voltage reading should be battery voltage or less depending on fuel level. If the reading is incorrect, replace fuel gauge (**Figure 26-15, Page 26-36**).



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Figure 26-14 Fuel Gauge Test

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Figure 26-15 Fuel Gauge Voltage Test

TEST PROCEDURE 23 – Hour Meter

See General Warnings on page 1-2.

NOTE: Keep the battery connected while performing this test procedure.

1. Place the neutral lockout cam in the MAINTENANCE position, put the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Turn the key switch to ON and record the current hour meter reading.
3. Press and hold the accelerator pedal to run the engine for at least six minutes (the meter records in six-minute increments). **See following DANGER.**

⚠ DANGER

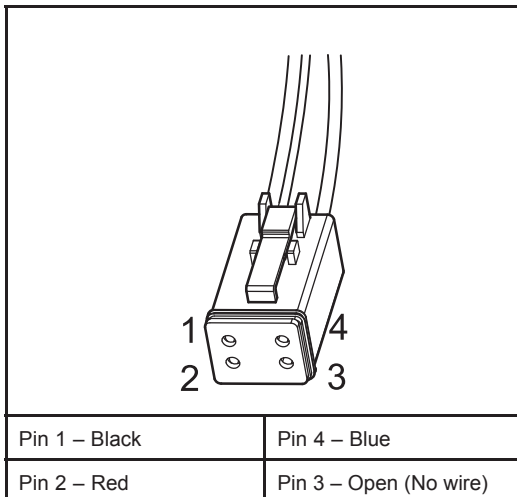
- Do not operate vehicle in an enclosed area without proper ventilation. The engine produces carbon monoxide, which is an odorless, deadly poison.
4. If the reading does not change after six minutes, then replace the hour meter.

TEST PROCEDURE 24 – 4-Pin Connector (for Connected Car Device)

See General Warnings on page 1-2.

NOTE: This is a voltage and continuity test.

The Connected Car Device 4-pin connector is used for Guardian/Visage and is labeled “V3 circuit” on the main wire harness.



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Figure 26-16 4-Pin Connector

1. If necessary, see Testing Basics on page 19-7.
2. Check for continuity between pin 1 (black wire) (**Figure 19-20, Page 19-31**) and pin 18 (black wire) of the black 18-pin connector on the ECU. It should indicate continuity. If not, check sonic welds no. 4, 10, and 14.
3. Probe pin 2 (red wire). It should show battery voltage with the key switch in the ON position. If not, check 2-amp fuse near ATM fuse holder. **See following NOTE.**

NOTE: The red wire only has battery voltage with the key switch in the ON position.

4. Probe pin 4 (blue wire). It should show approximately 11.8 volts supplied by pin 8 (blue/white wire) of the black 18-pin connector on the ECU. If not, check wiring and then ECU. **See following NOTE.**

NOTE: The blue wire only has voltage with the key switch in the ON position.

If pin 4 has no voltage, the ECU LIN (Local Interconnect bus) may have failed. The vehicle can be driven if it is not used with Guardian or Visage and will not show any symptoms. Otherwise, Guardian or Visage will disable the vehicle until communication is restored.

⚠ DANGER

- See General Warnings on page 1-2.

⚠ WARNING

- See General Warnings on page 1-2.

STARTER/GENERATOR

TESTING THE STARTER/GENERATOR

See Test Procedure 11 – Starter/Generator (Starter Function) on page 19-18.

See Test Procedure 10 – Starter/Generator (Generator Function) on page 19-17.

STARTER/GENERATOR REMOVAL

1. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Place the neutral lockout switch in the MAINTENANCE position. Access the engine compartment by removing the seat or raising the cargo bed.
3. Disconnect the wires from the starter/generator (1) (**Figure 27-14, Page 27-13**).
4. Loosen the pivot nuts (7) and bolts (5) (**Figure 27-13, Page 27-12**).
5. Remove the adjustment nut (4), washer (6) and adjustment bolt (1) (**Figure 27-13, Page 27-12**). Lower the starter/generator and remove the belt (2) from the pulley.
6. Support the starter/generator so that when the pivot bolts (5) are removed the starter/generator will not fall. Remove the two pivot nuts (7) and bolts (5) from the mounting bracket.
7. Remove the starter/generator.

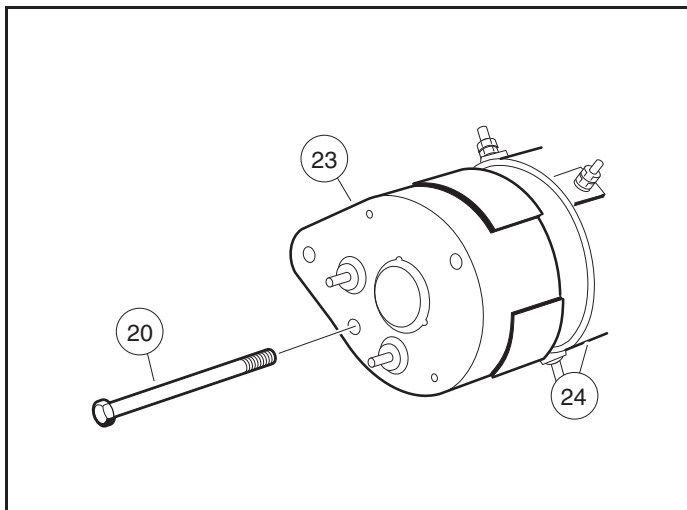
DISASSEMBLY OF THE STARTER/GENERATOR TO SERVICE THE BRUSHES

1. Remove the two bolts (20) and pull commutator end cover (23) free of starter/generator housing (24) (**Figure 27-1, Page 27-2**). **See following NOTE.**

NOTE: If the brushes are not removed, contact between the brushes and commutator as the commutator end cover is being removed or installed could damage the brushes. Lift the brush springs out of the notches in the brushes and pull the brushes back from the center of the commutator end cover. The springs will rest on the sides of the brushes and help prevent them from sliding towards the center of the cover (**Figure 27-5, Page 27-4**).

2. Remove brush covers (29 and 30), terminal hardware (25), brush springs (28), and brushes (27) (**Figure 27-2, Page 27-2**). **See following NOTE.**

NOTE: To clean and inspect the armature/commutator and the bearings, see **Disassembly of the Starter/Generator to Service the Armature/Commutator on page 20-7**.



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Figure 27-1 Commutator End Cover

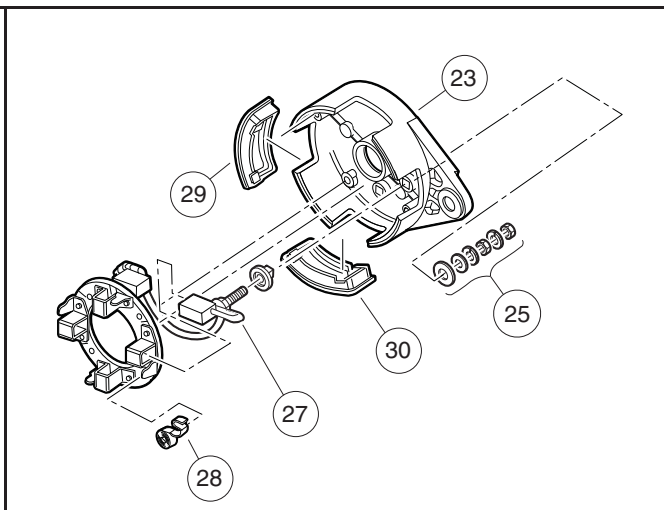


Figure 27-2 Brush Covers and Brushes

BRUSH INSPECTION AND REPLACEMENT

1. Visually inspect brushes. Replace brushes that are cracked or severely chipped.
2. Measure the length of each brush. Replace the brush set if a brush is less than 0.375 inch (9.5 mm) (**Figure 27-3, Page 27-2**).

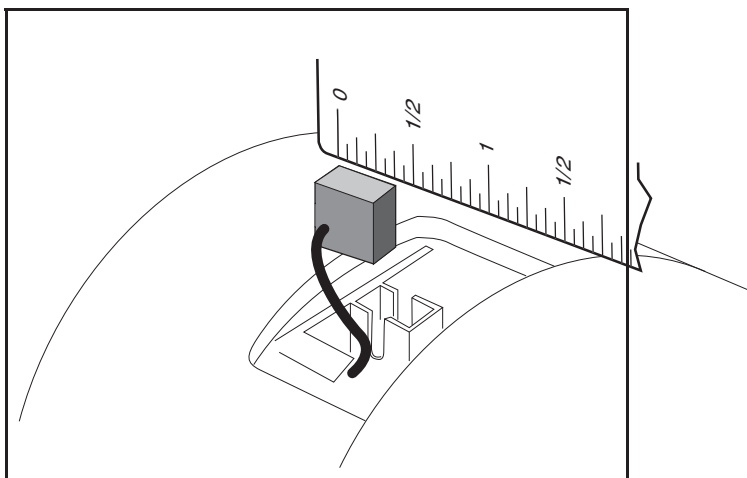


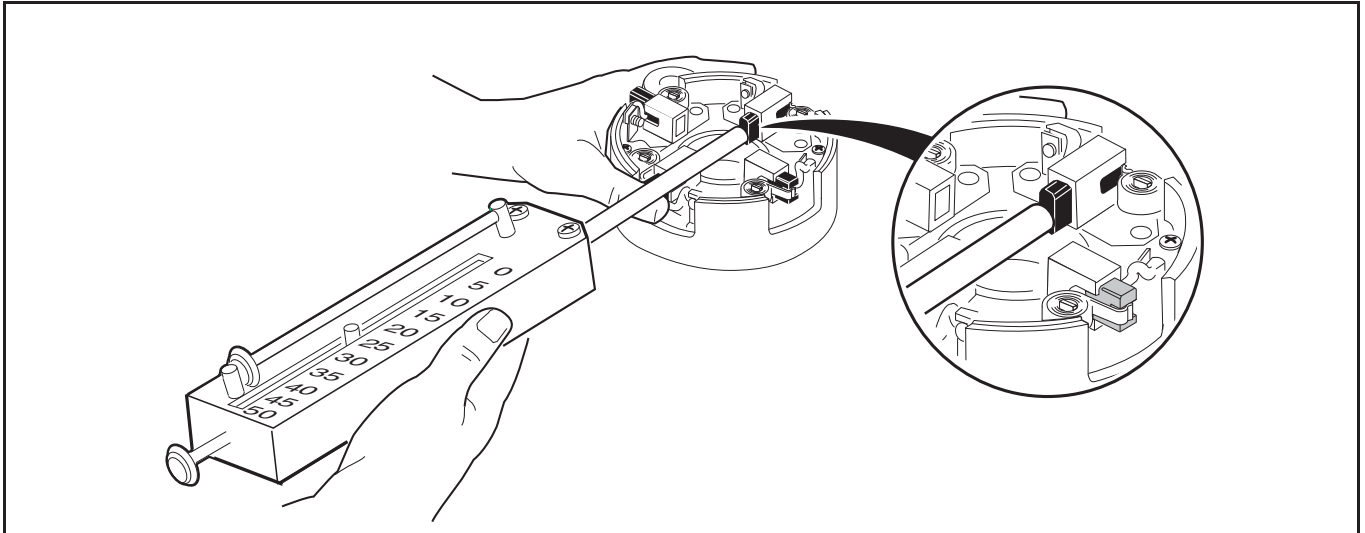
Figure 27-3 Inspect Brushes and Measure Length

BRUSH SPRING INSPECTION AND REPLACEMENT

1. Visually inspect springs. Replace all four springs if any spring is discolored from heat (straw or bluish in color).
2. Install the four brushes (27) into their holders and insert the four brush springs (28) (**Figure 27-2, Page 27-2**). Using a spring scale, test brush spring tension. If any spring has a tension less than 24 ozf (0.68 kgf), replace all four springs (**Figure 27-4, Page 27-3**). **See following CAUTION.**

⚠ CAUTION

- When checking brush spring tension, do not push springs beyond the point they would normally be if there were new brushes installed. Exerting excessive force or pushing brush springs beyond their normal maximum extension point will damage springs.



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Figure 27-4 Brush Spring Tension Test

STARTER/GENERATOR ASSEMBLY

1. Install the brushes (27) into the holders. Install the terminal hardware (25) (**Figure 27-2, Page 27-2**).
2. To prevent contact between the brushes and commutator as the commutator is installed, and possible damage to the brushes, lift the brush springs and pull the brushes back from the center of the commutator end cover. The springs will rest on the sides of the brushes and help prevent them from sliding towards the center of the cover (**Figure 27-5, Page 27-4**).
3. Install the commutator end cover (23) onto the armature shaft. Align the locating pin with the pin hole in the cover. Install two M6 x 180 mm bolts (20) and tighten to 100 in·lb (11.3 N·m) (**Figure 27-1, Page 27-2**).
4. Push the brushes down into the holders. Position springs on the end of the brushes. Install the brush cover (30) that has the drain hole in it next to the A2 terminal. Install the remaining three brush covers (29) in the openings in the commutator end cover (23) (**Figure 27-2, Page 27-2**).

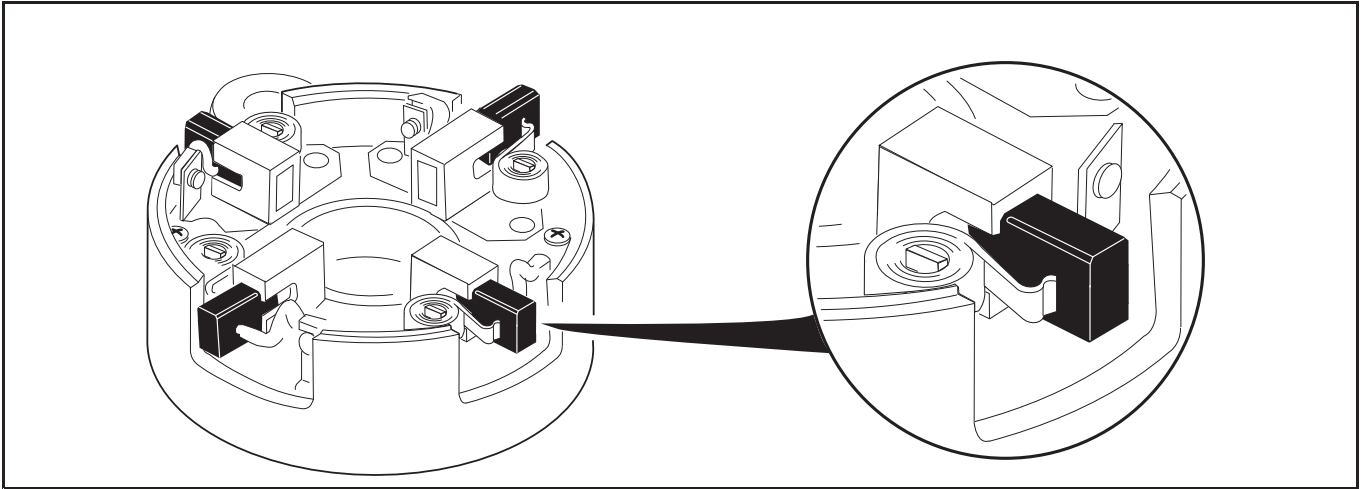
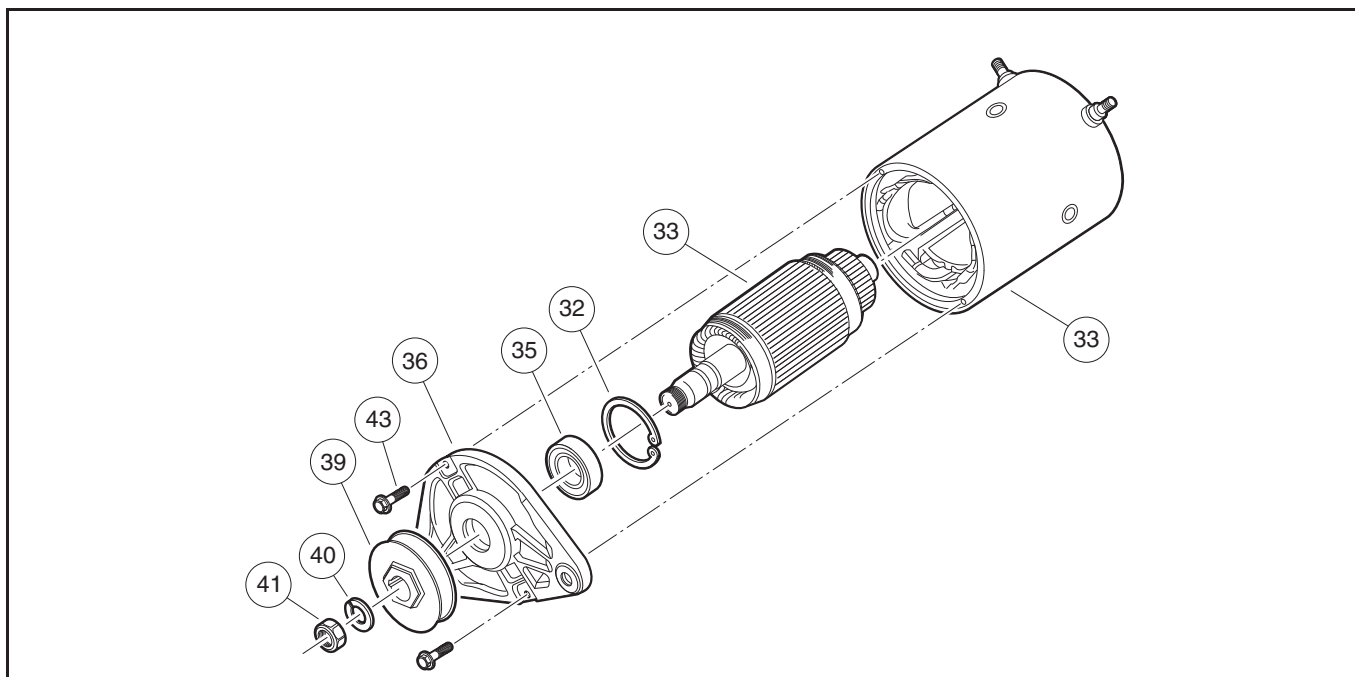


Figure 27-5 Pull Brushes Away From Center of the Commutator End Cover

DISASSEMBLY OF THE STARTER/GENERATOR TO SERVICE THE ARMATURE/COMMUTATOR

1. Remove the commutator end cover to prevent damage to the brushes and armature. **See Commutator End Cover on page 27-2.**
2. To separate armature and output end cover assembly from the field coil housing, first remove the two securing bolts (43). Carefully remove armature and output end cover assembly from the field coil housing so components are not damaged.
3. To separate armature (33) from output end cover (36), remove nut (41), lock washer (40), pulley (39). It may be necessary to use the wedge attachment tool to remove the pulley from the shaft.
4. Remove the internal retaining ring (32) to release the bearing (35) and armature (33) from the output end cover (36). **(Figure 20-5, Page 20-8).**

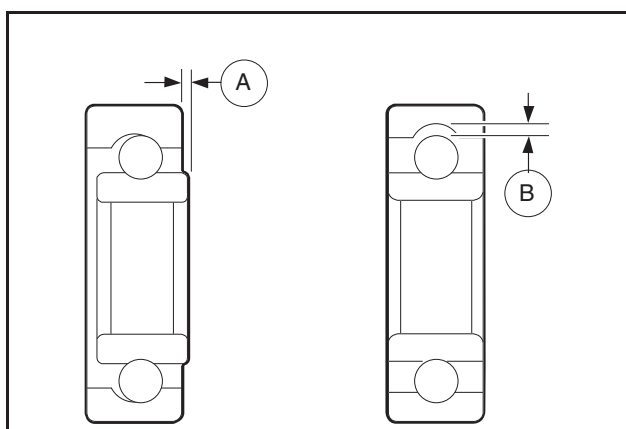


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Figure 27-6 Output End Cover Assembly, Armature and Housing

BEARING CLEANING AND INSPECTION

1. Using a clean cloth, wipe the carbon dust from the two bearings. Inspect bearings by spinning them by hand and checking for both axial (A) and radial (B) play (**Figure 27-7, Page 27-5**).
2. Replace the bearing if it is noisy, does not spin smoothly, or has excessive play. Check the bearings and replace if rusted, worn, cracked, or if there is an abnormal color change in the metal of the bearing. Bearings should be replaced if there is extensive wear or pitting on the balls or on the rolling surfaces. Do not remove the bearings unless they are to be replaced.

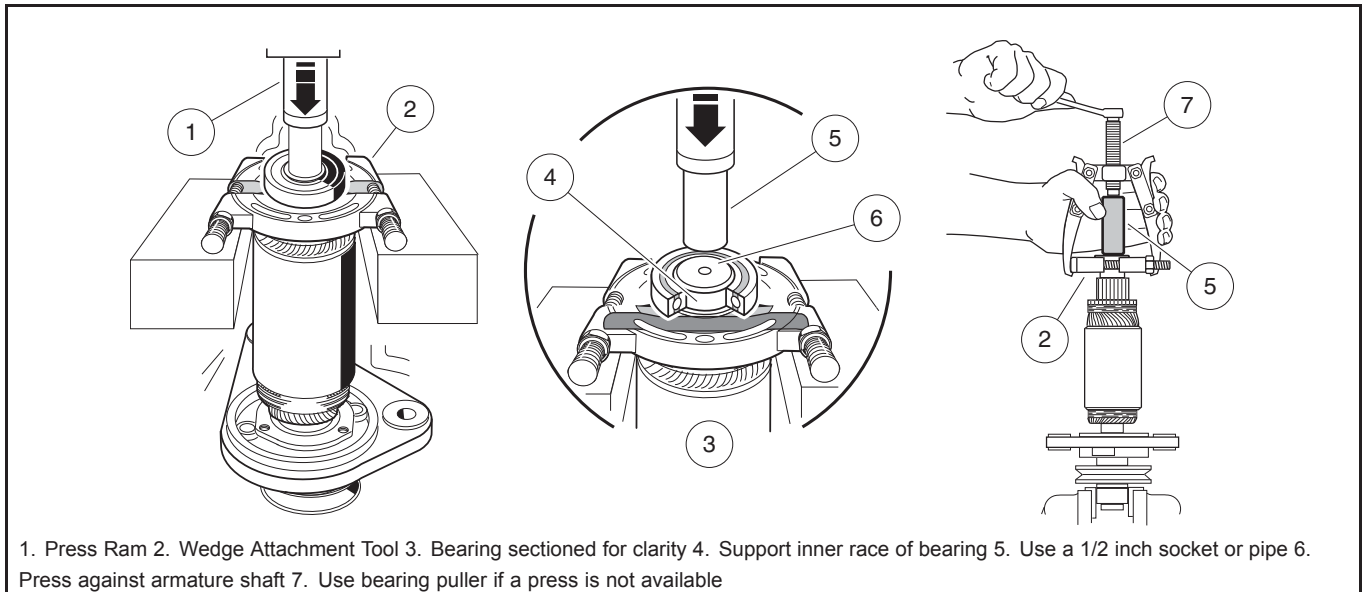


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Figure 27-7 Bearing Play Inspection

BEARING REMOVAL

1. Place the wedge attachment tool between the bearing and the armature. Make sure the wedge attachment tool is supporting the inner race of the bearing. If a press is not available, secure a bearing puller to the wedge attachment tool and pull the bearing off of the end of the armature shaft. Support the armature so that it will not drop when the bearing is removed (**Figure 27-8, Page 27-6**).
2. Slide the bearing retainer ring (32) off of the output end of the shaft (**Figure 20-5, Page 20-8**).



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Figure 27-8 Bearing Removal

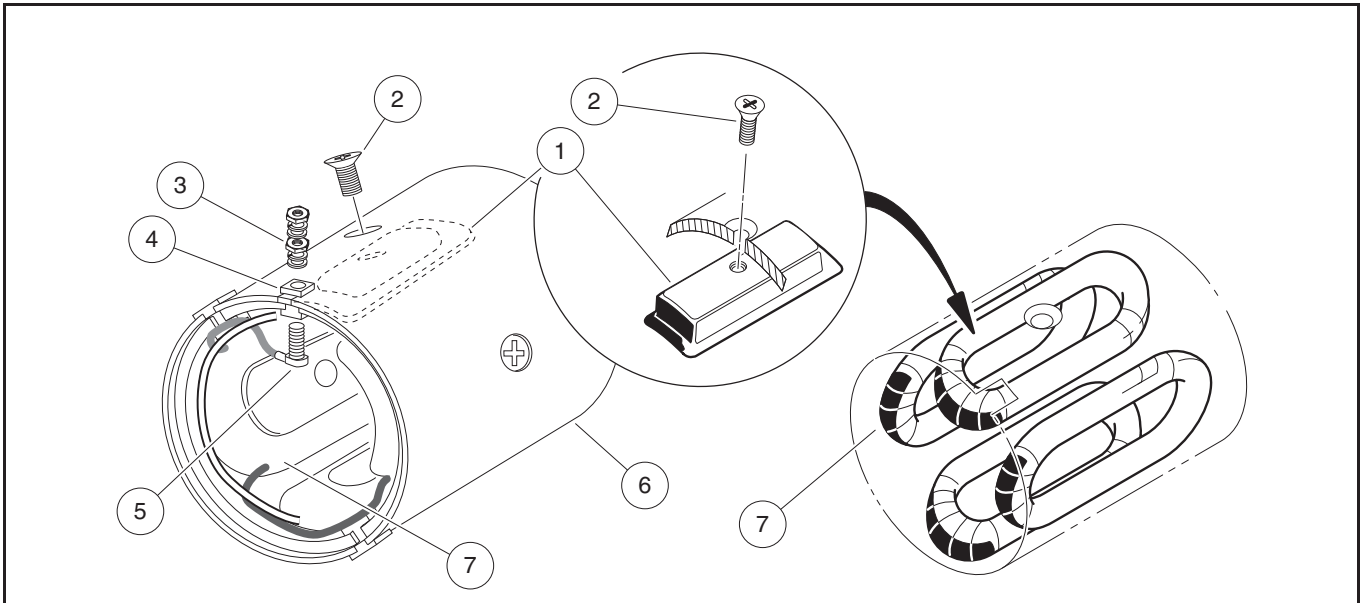
FIELD COIL ASSEMBLY

Replace entire field coil housing assembly if coils, pole shoes or terminals are damaged. (**Figure 27-9, Page 27-7**).

VISUAL INSPECTION OF ARMATURE

Obvious defects can be seen by examining the armature. If an armature has frayed or charred insulation, broken wires or thrown solder, it is obvious without testing that it should be replaced. Faults seen during the visual inspection can aid in diagnosing the original cause of the failure. Items to look for are listed below.

- Burned, charred, or cracked insulation
- Improperly cured varnish
- Thrown solder
- Flared armature windings
- Worn, burned, or glazed commutator
- Loose or raised commutator bars
- Bruised or damaged armature core laminations
- Worn armature bearing or shaft
- Dirty or oily commutator



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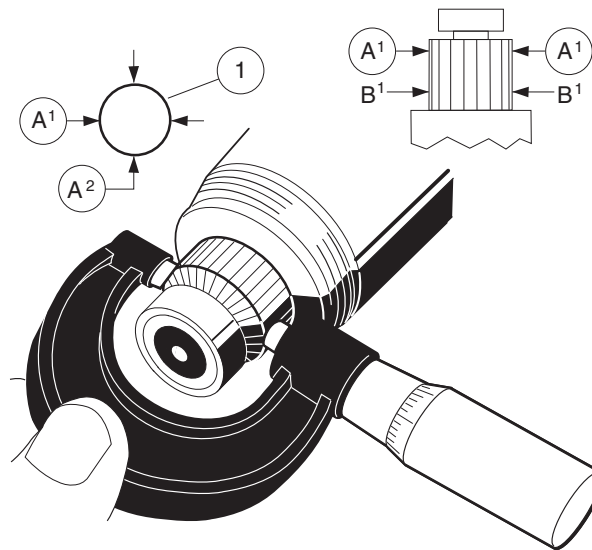
Figure 27-9 Field Coil Assembly

COMMUTATOR CLEANING AND INSPECTION

1. Clean the carbon dust, dirt and oil from the commutator. Visually inspect the commutator for worn, burned or glazed areas. Check for loose or raised commutator bars. Slight roughness of the commutator can be polished away with 400 grit (or finer) sandpaper. **See following CAUTION.**

⚠ CAUTION

- Do not use emery cloth on the commutator. Particles of emery are conductive and may short-circuit the commutator bars. Do not use oil or lubricants on the commutator or brushes.
2. Using a micrometer, measure the outside diameter at two points along the commutator. If the commutator outside diameter is less than 1.535 inches (39 mm), replace the armature and bearings (**Figure 20-7, Page 20-10**).



1. Measure each position in two places, 90 degrees apart

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Figure 27-10 Inspect Commutator

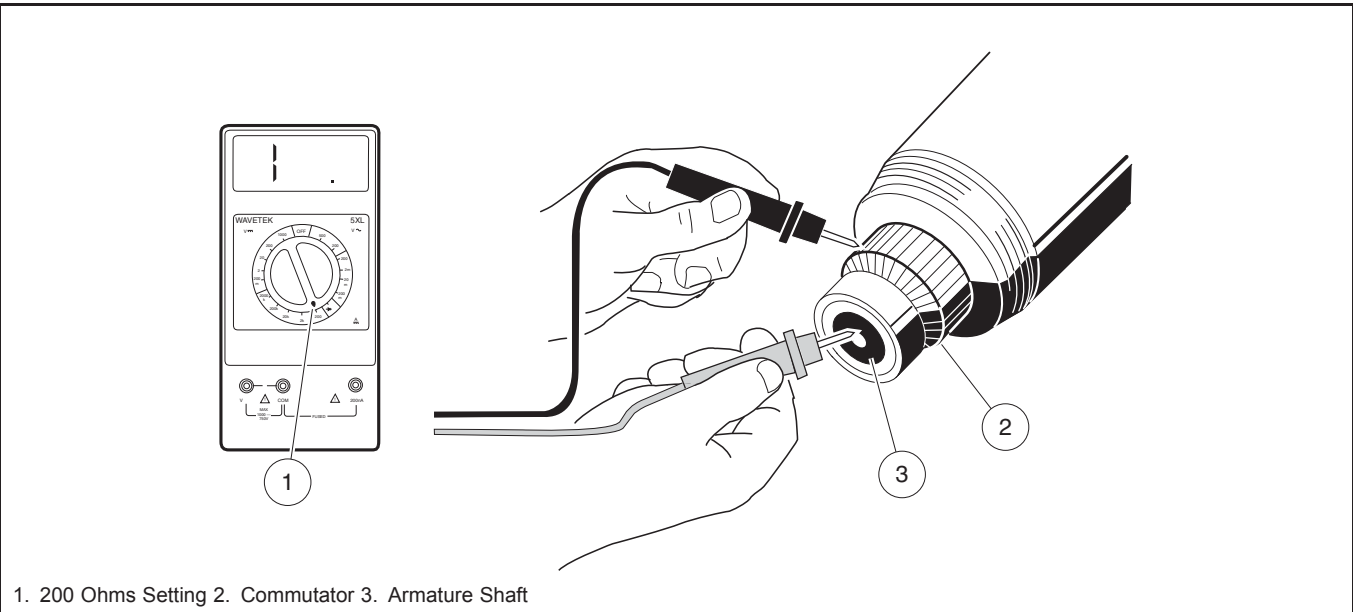
ARMATURE GROUND TEST

⚠ CAUTION

- Do not submerge armature in solvent.

NOTE: Before testing, wipe the armature with a clean cloth and remove carbon dust and metal particles from between commutator bars.

Using a multimeter set on 200 ohms, place the positive (+) probe on the commutator bars and the negative (–) probe on the armature core. The reading should be no continuity. If the reading is incorrect, replace the armature and the two bearings (Figure 27-11, Page 27-9).



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Figure 27-11 Armature Ground Test

VISUAL INSPECTION OF FIELD COILS

If the insulation on the field coils appears blackened or charred, the serviceability of the coils is questionable. Burned or scorched coil insulation indicates the starter/generator has overheated due to overloads or grounded or shorted coil windings. Be sure the insulators are tight in the housing.

STARTER/GENERATOR REWORK

Any rework must be performed by a qualified technician. Starter/generator service specifications are listed in the following table.

| ITEM | SERVICE LIMIT |
|---|------------------------|
| Commutator diameter (minimum) | 1.60 in. (41 mm) |
| Concentric with armature shaft within | 0.002 in. (0.051 mm) |
| Minimum commutator diameter for reslotting | 1.65 in. (42 mm) |
| Undercut (Commutator must have a minimum diameter of 1.65 in (42 mm) for reslotting): | 0.050 in. (1.3 mm) |
| Dielectric strength | 500 VAC for one minute |
| Armature insulation resistance | 0.2M (ohms) at 500 VDC |
| Starter field coil resistance | 0.006 to 0.01 ohms |
| Generator field coil resistance | 4.5 to 5.5 ohms |

STARTER/GENERATOR ASSEMBLY

1. Slide the bearing retainer (32) onto the output end of the armature shaft (33) (Figure 20-5, Page 20-8).

2. Press a new ball bearing (35) onto the output end of the armature (**Figure 20-5, Page 20-8**). Press a new ball bearing onto the commutator end of the armature shaft. **See following CAUTION.**

⚠ CAUTION

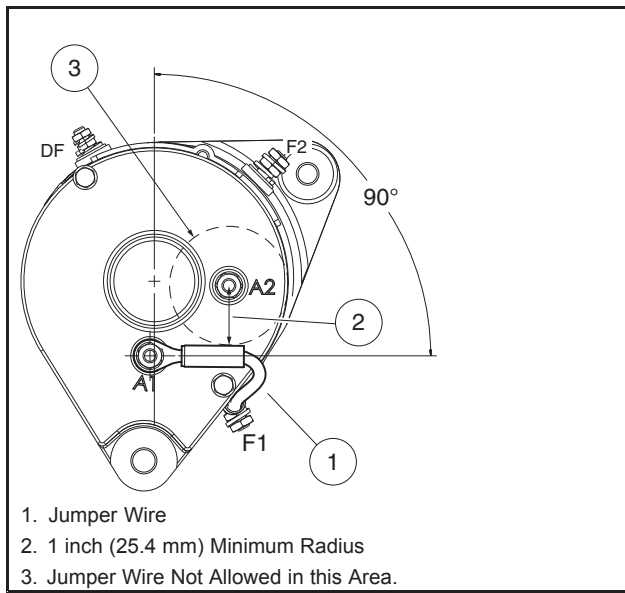
- To prevent damage to the retainer, use care while pressing new bearing onto the output end of the shaft.
 - Press against the inner race of the new bearing until it is fully seated.
3. Install the drive end cover (36) onto the armature. Secure the bearing retainer ring (32) (**Figure 20-5, Page 20-8**).
 4. Slide the housing with field coils over the armature. Use the tapped mounting holes to align housing to the cover, rotate and orient as shown.

NOTE: The terminal insulators should be on the commutator end of the housing.

5. To prevent contact between the brushes and commutator as the commutator cover is installed, and possible damage to the brushes, lift the brush springs out of the notches in the brushes and pull the brushes back from the center of the commutator end cover. The springs will rest on the sides of the brushes and help prevent them from sliding towards the center of the cover (**Figure 27-5, Page 27-4**).
6. Install the commutator end cover (23) onto the armature shaft. Use the tapped mounting holes to align housing to the cover, rotate and orient as shown. Install the two M6 x 180 mm bolts (20), and tighten to 60 in·lb (6.8 N·m) (**Figure 27-1, Page 27-2**).
7. Push the brushes down into the holders. Place springs into the notches in the brushes. Install the brush cover (30) that has the drain hole in it next to the A2 terminal. Install the remaining three brush covers (29) in the openings in the commutator end cover (23) (**Figure 27-2, Page 27-2**).
8. Install the belt pulley (39) onto the shaft, and install the lock washer (40) and M14 nut (41). Tighten the nut to 30 ft·lb (40.7 N·m) (**Figure 20-5, Page 20-8**).
9. Install the A1 to F1 terminal jumper wire on the starter/generator.
 - 9.1. Loosely attach wire, flat washers, lock washers and nuts onto each terminal.
 - 9.2. Orient wire at A1 to be 1 inch (25.4 mm) away from A2 terminal as shown and tighten nut to 44 in·lb (5 N·m) (**Figure 20-11, Page 20-14**). **See following NOTE.**

NOTE: Secure bottom nut of terminal with wrench before tightening top nut.

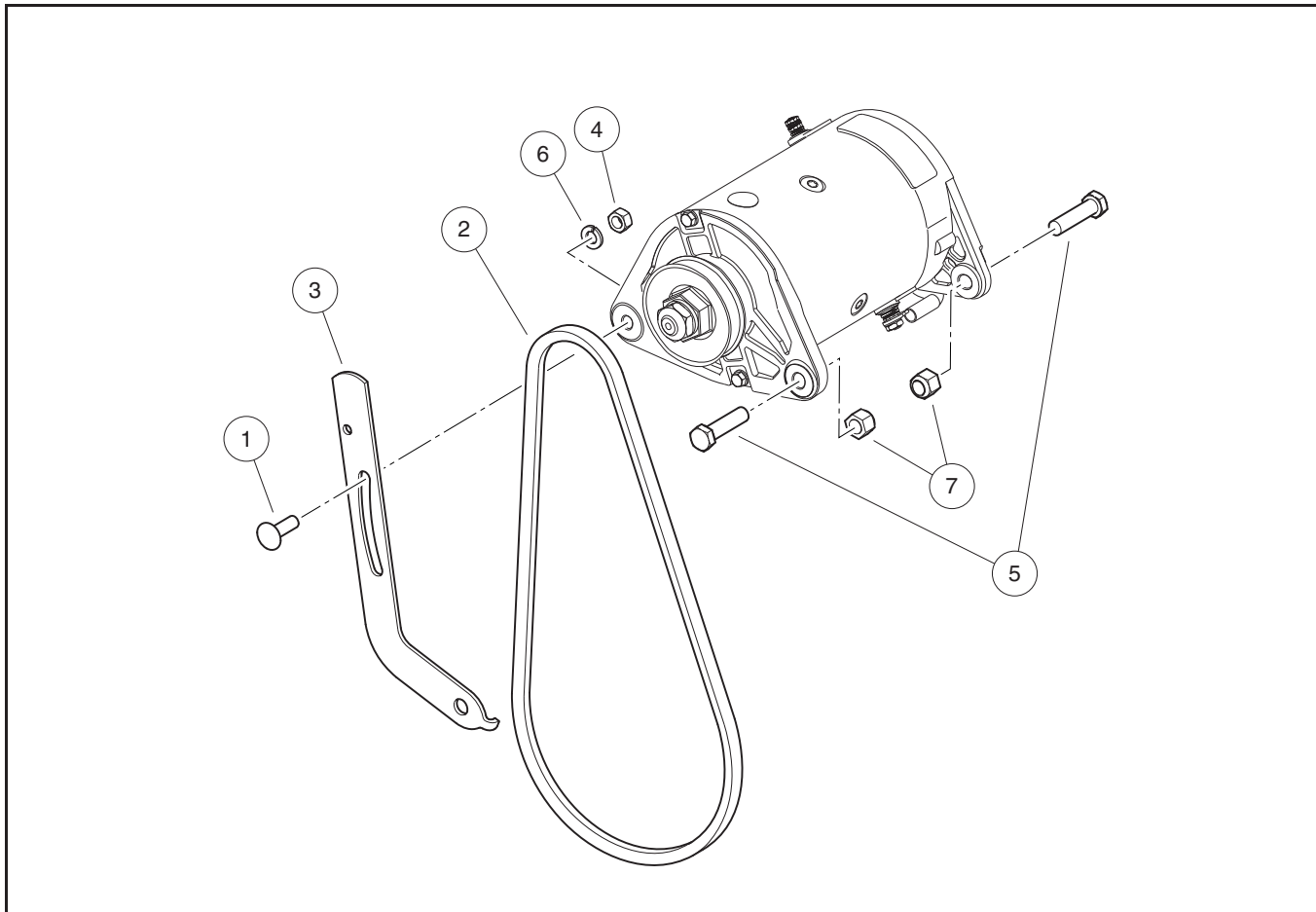
- 9.3. Form wire against starter housing as shown and allow terminal at F1 to self-orient. Tighten nut to 44 in·lb (5 N·m). **See preceding NOTE.**



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Figure 27-12 A1 to F1 Terminal Jumper Wire Routing

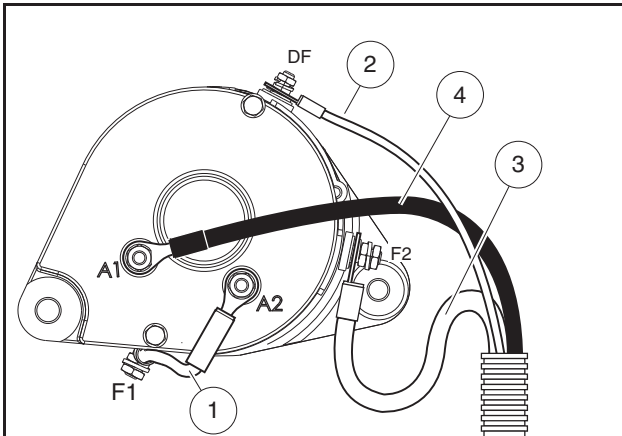
STARTER/GENERATOR INSTALLATION



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Figure 27-13 Starter/Generator Installation

1. Install the green wire (1) from the F1 terminal to the A2 terminal on the starter/generator (**Figure 27-14, Page 27-13**). Install a flat washer, lock washer, and nut onto each terminal and tighten to 48 in·lb (5.4 N·m).
2. Position the starter/generator over the mounting bracket so that the bolts will go through the starter/generator before going through the bracket. Install pivot bolts (5) with the heads of the bolts facing as shown (**Figure 27-13, Page 27-12**). Install lock nuts (7) finger-tight.
3. Install the adjustment bolt (1) through the adjusting bracket (3) and then through the starter/generator. Install a lock washer (6) and nut (4) onto adjustment bolt (1) finger-tight (**Figure 27-13, Page 27-12**).
4. Install starter/generator belt (2) and adjust belt tension as instructed. **See Belt Tension Adjustment For EFI Engines on page 20-16.**
5. Connect the yellow wire (2) from the voltage regulator to the DF terminal on the starter/generator (**Figure 27-14, Page 27-13**). Install a flat washer, lock washer, and nut onto the terminal. Tighten the nut to 31 in·lb (3.5 N·m).
6. Install the white wire (3) from the solenoid to the F2 terminal on the starter/generator (**Figure 27-14, Page 27-13**). Install the black wire (4) from the frame to the A1 terminal on the starter/generator. Install a flat washer, lock washer and nut onto each terminal, and tighten the nut to 48 in·lb (5.4 N·m).
7. Connect battery and spark plug wire(s). **See Connect the Battery - Gasoline Vehicles on page 1-4.**



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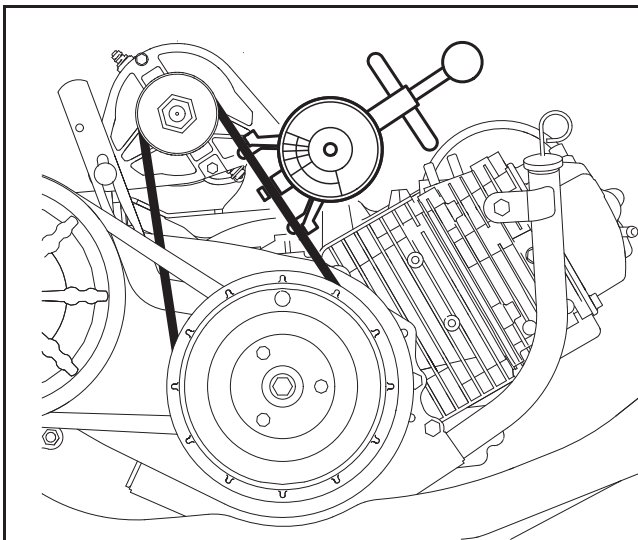
Figure 27-14 Starter/Generator Wiring

BELT TENSION ADJUSTMENT FOR EFI ENGINES

NOTE: To prevent belt slipping while starting an EFI engine, follow procedure outlined below which is best performed by two people to expedite the process, but can be performed by a single individual if required.

The amount a starter/generator belt is tensioned varies between a used and new belt.

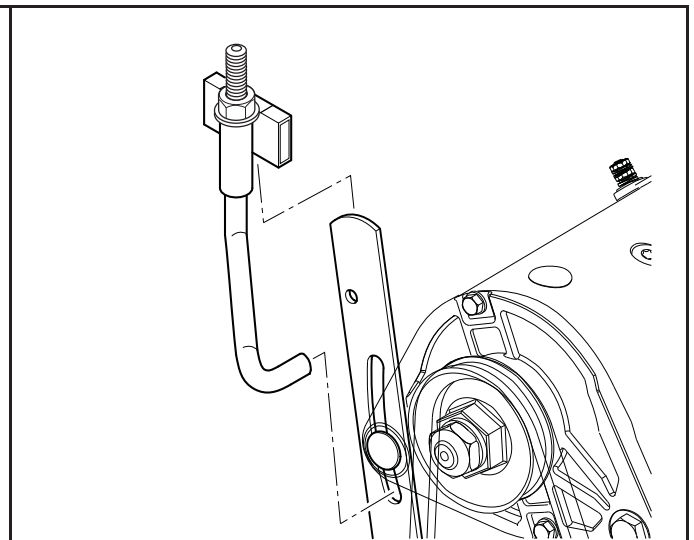
EFI engines have higher starting torque demands that require consistent belt tension to prevent slipping. Belt tension should be checked periodically.



Locate gauge midway between pulleys.

2724

Figure 27-15 Belt Tension Gauge



2725

Figure 27-16 Belt Tensioning Tool Installation

1. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. Access engine compartment.
 - Remove seat and rear access panel (if equipped).
 - Raise cargo bed (if equipped).

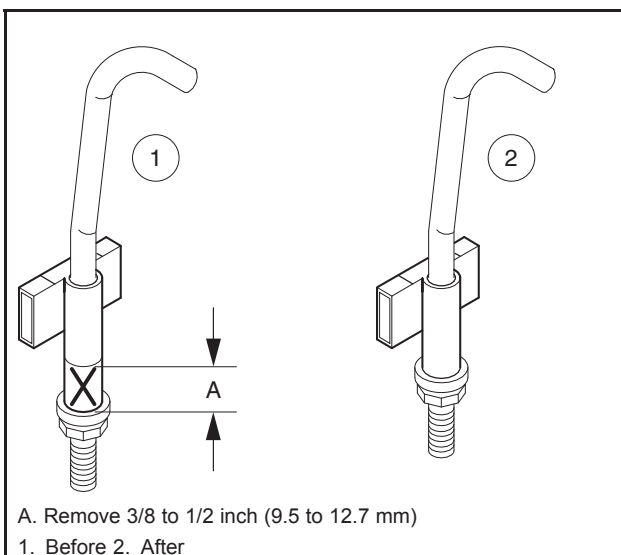
- Use combination of above methods.
- 3. Mark a location on belt to repeat tension measurement each time. Use paint pen or permanent marker of light color.
- 4. **For Existing Belts Only:** Verify current belt tension using Universal Belt Tension Gauge (OTC® 6673 recommended) (**Figure 27-15, Page 27-13**). Proper tension for a used starter/generator belt is 75 to 85 lbf (334 to 378 N).
 - If belt tension is within accepted range, no further action is needed. Connect battery and spark plug wire(s). **See Connect the Battery - Gasoline Vehicles on page 1-4.**
 - If belt tension is not within accepted range, continue procedure. **See following NOTE.**

NOTE: To expedite procedure for existing belt and avoid need for a pry bar, first install belt tension tool and then loosen starter/generator mounting hardware.

5. Tighten starter/generator mounting hardware (4 and 7) finger-tight (**Figure 27-13, Page 27-12**).
6. Install belt tension tool.
 - 6.1. Carefully insert pry bar between starter/generator and bracket.
 - 6.2. Carefully lift starter up until tension tool can be installed as shown over the slotted adjustment bracket (**Figure 27-16, Page 27-13**). Note orientation of tension tool on the slotted adjustment bracket and how the threaded J-bolt is inserted into the slot under the starter/generator mounting ear.

NOTE: In some cases, the threaded J-bolt of the belt tension tool does not have enough length to consistently fit under the starter/generator mounting ear. Fit can be greatly improved by modifying the tension tool using the following procedure.

- Remove nut and J-bolt from bracket.
 - Grind or cut $\frac{3}{8}$ to $\frac{1}{2}$ inch (9.5 to 12.7 mm) from bracket as shown to increase the effective length of the J-bolt (**Figure 27-17, Page 27-14**).
 - Install J-bolt and nut into bracket.
- 6.3. Remove pry bar.



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Figure 27-17 Belt Tension Tool Modification (If Necessary)

7. Tension belt.

- 7.1. Tighten nut on belt tension tool 1/2 turn and check belt tension with gauge (**Figure 27-15, Page 27-13**).

NOTE: To prevent errors in measurement caused by residual tension, ensure to loosen, then reapply, the Universal Belt Tension gauge between measurements.

- 7.2. Continue to tighten in 1/2 turn increments until proper belt tension is achieved.
- Proper tension for a **used** starter/generator belt is 75 to 85 lbf (334 to 378 N).
 - Proper tension for a **new** starter/generator belt is 120 to 130 lbf (534 to 578 N).
8. Seat the belt.
- 8.1. Remove all other tools.
- 8.2. The belt tension tool can be temporarily left in place.
- 8.3. Connect battery only. **DO NOT CONNECT SPARK PLUG WIRE. See Connect the Battery - Gasoline Vehicles on page 1-4. See following WARNING.**

⚠ WARNING

- **Remove pry bar before starting engine.**
- **Ensure clearance between F2 terminal and starter/generator bracket before starting engine.**

- 8.4. Engage starter and crank engine a minimum of 5 seconds and a maximum of 15 seconds to fully seat the belt into pulleys and help eliminate any slack.
9. Repeat step 7.
10. Maintain tension and tighten adjustment nut (4) to 15 to 18 ft·lb (20 to 24.5 N·m). Tighten hex nuts (7) to 20 to 25 ft·lb (27 to 34 N·m) (**Figure 27-13, Page 27-12**).
11. Remove belt tension tool.
12. Confirm proper belt tension with a final measurement.
13. Connect spark plug wire.

VOLTAGE REGULATOR

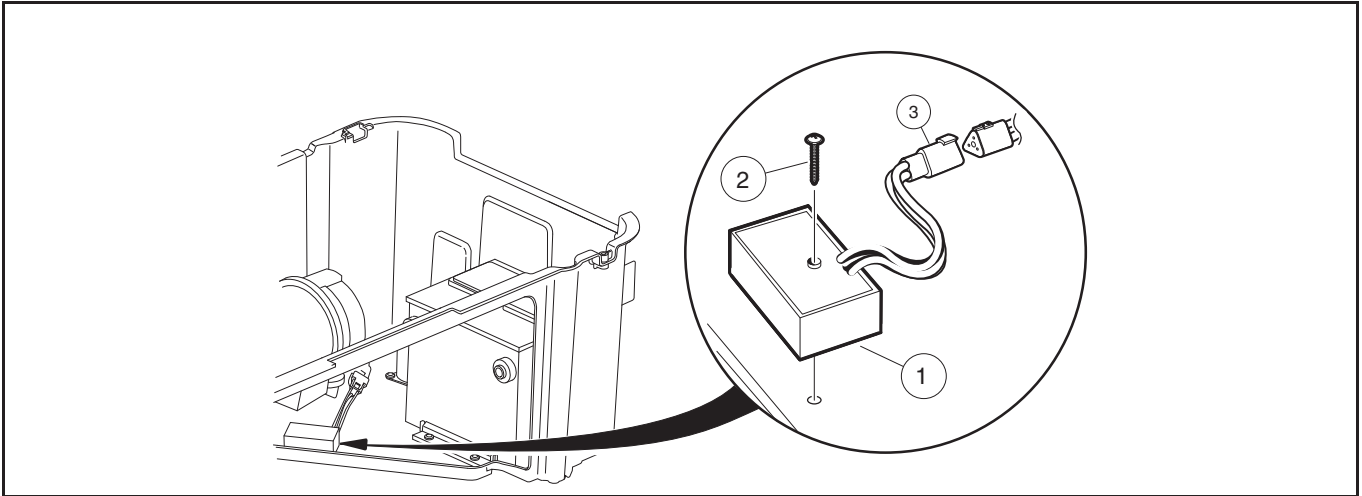
See General Warnings on page 1-2.

TESTING THE VOLTAGE REGULATOR

See Test Procedure 12 – Voltage Regulator on page 19-20.

VOLTAGE REGULATOR REMOVAL

1. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
2. Disconnect the voltage regulator connector (3) from the wire harness (**Figure 20-22, Page 20-21**).
3. Remove the voltage regulator mounting screw (2) and remove the voltage regulator (1).



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Figure 27-18 Voltage Regulator

VOLTAGE REGULATOR INSTALLATION

1. Position the voltage regulator (1) and install the mounting screw (2) (**Figure 20-22, Page 20-21**). Tighten screw to 23 in·lb (2.6 N·m).
2. Connect the voltage regulator three-pin connector (3) to the wire harness.
3. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.
4. Place Forward/Reverse handle in NEUTRAL and place the neutral lockout cam in the MAINTENANCE position. Start the engine and check regulator for proper functioning as described in the voltage regulator test procedure.
See Test Procedure 12 – Voltage Regulator on page 19-20.

ENGINE CONTROL UNIT (ECU)

CAUTION

- The Engine Control Unit (ECU) and Throttle Body are to be purchased as one unit. They are matched pairs with matching serial numbers. Do not mix an ECU with another Throttle Body of a different serial number. Doing so violates emissions standards and warranty.

The ECU is located in the engine compartment.

TESTING THE ENGINE CONTROL UNIT

See Test Procedure 4 – EFI System (ECU and Sensors) on page 26-18.

ENGINE CONTROL UNIT REMOVAL

1. Disconnect battery.
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
2. Remove ECU mounting plate bolts.
3. Disconnect gray and black wire connectors.

ENGINE CONTROL UNIT INSTALLATION

⚠ WARNING

- To prevent damage to the ECU, never mix the black and gray connectors that attach to it. The black connector is tethered to the ECU mounting plate to help prevent accidentally installing it in the gray port.
1. Mount ECU to plate with bolts and tighten to 60 in·lb (6.8 N·m).
 2. Install gray connector to the gray port on the ECU. **See preceding WARNING.**
 3. Install black connector to the black port on the ECU.
 4. Connect the battery.

KEY SWITCH

See General Warnings on page 1-2.

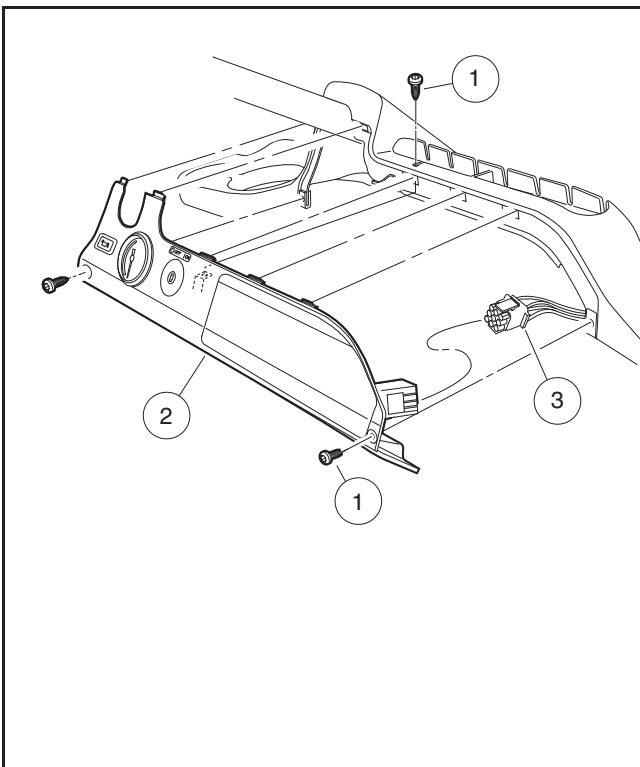
TESTING THE KEY SWITCH

See Test Procedure 4 – Key Switch (Start Circuit) on page 19-11.

See Test Procedure 5 – Key Switch (Engine Kill Circuit) on page 19-11.

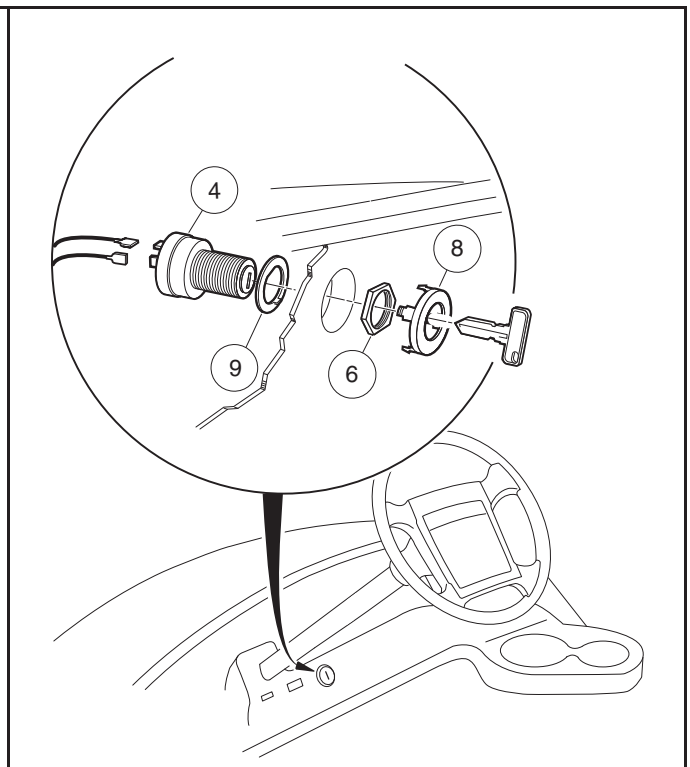
KEY SWITCH REMOVAL

1. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
2. Remove the instrument panel.
 - 2.1. Remove three screws (1) from the instrument panel (2) (**Figure 27-19, Page 27-18**).
 - 2.2. Rotate the instrument panel up and away from the dash to disengage the tabs at the top of the instrument panel.
 - 2.3. Disconnect the electrical connector (3) to the instrument panel.



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Figure 27-19 Instrument Panel Removal



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Figure 27-20 Key Switch

3. Disconnect the wires from the key switch.
4. From the back of the instrument panel, push down on the retaining tabs surrounding the key switch (4) and remove the key switch cap (8). Hold the key switch and remove the switch retaining nut (6) from the outside of the instrument panel (**Figure 27-20, Page 27-18**).

KEY SWITCH INSTALLATION

1. Reverse removal procedures to install key switch in the instrument panel. Connect wires to key switch.
2. Install the instrument panel.
 - 2.1. Connect the electrical connector (3) **(Figure 27-19, Page 27-18)**.
 - 2.2. Position the instrument panel (2) on the dash assembly. Make sure tabs on upper edge properly engage with the corresponding slots on the dash assembly. Ensure that there are no wires exposed or pinched during positioning.
 - 2.3. Secure instrument panel to the dash assembly with three screws (1). Tighten screws to 1.8 ft·lb (2.5 N·m).
3. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.

MAINTENANCE/OPERATE SWITCH

TESTING THE MAINTENANCE/OPERATE SWITCH

See Test Procedure 8 – Maintenance/Operate Switch on page 19-15.

MAINTENANCE/OPERATE SWITCH REMOVAL

1. Disconnect the battery and spark plug wire(s).
2. Using a 5/8 inch (16 mm) wrench, remove maintenance/operate boot/hex nut.
3. Remove maintenance/operate switch from bracket.
4. Disconnect the three spade terminals and remove switch.

MAINTENANCE/OPERATE SWITCH INSTALLATION

1. Connect the three spade terminals **(Figure 19-6, Page 19-15)**.
2. Make sure groove switch is aligned with tang on bracket and install switch. Tighten maintenance/operate switch boot/hex nut to 16 in·lb (1.8 N·m).
3. Connect the battery.

NEUTRAL LOCKOUT LIMIT SWITCH

See General Warnings on page 1-2.

TESTING THE NEUTRAL LOCKOUT LIMIT SWITCH

See Test Procedure 9 – Transaxle Limit Switch on page 19-16.

NEUTRAL LOCKOUT LIMIT SWITCH REMOVAL

1. Turn the key switch OFF and remove the key. Place the Forward/Reverse handle in the NEUTRAL position. Chock the wheels.
2. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
3. Disconnect the 3-wire connector from the neutral lockout limit switch (1) located on the transaxle.
4. Remove two nuts (3) and washers (4) from the neutral lockout limit switch (1) and slide the limit switch off of the screws.

NEUTRAL LOCKOUT LIMIT SWITCH INSTALLATION

1. Install the limit switch (1) with washers (4) and nuts (3) and tighten to 5 in·lb (0.6 N·m). Move the Forward/Reverse handle to make sure the switch actuates. **See following CAUTION.**

CAUTION

- Do not overtighten the retaining nuts. If the nuts are overtightened, limit switches could be damaged.
2. Connect the 3-wire connector to the neutral lockout limit switch lead.
 3. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.
 4. Test drive the vehicle in both forward and reverse for proper operation.

SOLENOID

See General Warnings on page 1-2.

TESTING THE SOLENOID

See Test Procedure 7 – Solenoid on page 19-14.

SOLENOID REMOVAL

1. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
2. Disconnect all the wires from the solenoid.
3. Remove the two screws securing the solenoid in place.
4. Remove the solenoid.

SOLENOID INSTALLATION

1. Install the solenoid in the vehicle. Use two screws to secure the solenoid and tighten to 14 in·lb (1.6 N·m).
2. Connect the ring terminal with the 10-gauge white wire and the 16-gauge red wire on a large post on the solenoid.
See Sonic Weld and Diode Locations on page 26-10.
3. Connect the ring terminal with the two 10-gauge red wires to the other large post on the solenoid. **See Sonic Weld and Diode Locations on page 26-10.**
4. Connect the 16-gauge blue wire from the main harness to a small post on the solenoid.
5. Connect the 16-gauge orange wire from the main harness to the other small post on the solenoid. **See Sonic Weld and Diode Locations on page 26-10.**
6. Tighten the hex nuts on the large solenoid posts to 55 in·lb (6.2 N·m). Tighten the nuts on the small solenoid posts to 22 in·lb (2.5 N·m).
7. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.

FUSE

See General Warnings on page 1-2.

ATM-style blade fuses are located on the main wire harness in front of the battery.

The ABC-style glass fuse is located on the main wire harness adjacent to the ATM-fuse holder.

TESTING THE FUSE

See Test Procedure 2 – Fuse Inspection on page 19-10.

FUSE REMOVAL

1. Disconnect battery.
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
2. **ATM Fuses Only:** Remove fuse holder cover.
ABC Fuse Only: Open in-line fuse holder.
3. Remove the fuse.

FUSE INSTALLATION

1. Install the fuse. **See following WARNING.**

WARNING

- If a fuse is blown, determine the cause of the failure and make necessary repairs before installing a new fuse. Use the appropriately rated fuse; if a fuse with a higher amp rating is used, damage to the vehicle electrical system may occur.
2. **ATM Fuse Only:** Install the fuse holder cover.
ABC Fuse Only: Assemble in-line fuse holder.
 3. Connect battery.
See Connect the Battery - Gasoline Vehicles on page 1-4.

ACCELERATOR PEDAL LIMIT SWITCH

See General Warnings on page 1-2.

TESTING THE ACCELERATOR PEDAL LIMIT SWITCH

See Test Procedure 6 – Throttle Position Sensor (TPS) on page 19-12.

The accelerator pedal limit switch is housed inside the throttle position sensor. The throttle position sensor itself is not intended to be replaced. If sensor is determined to need replacing through test procedures found in this manual, the accelerator pedal assembly must be replaced.

KILL LIMIT SWITCH

See General Warnings on page 1-2.

TESTING THE KILL LIMIT SWITCH

See Test Procedure 6 – Throttle Position Sensor (TPS) on page 19-12.

The kill limit switch is housed inside the throttle position sensor. The throttle position sensor itself is not intended to be replaced. If sensor is determined to need replacing through test procedures found in this manual, the accelerator pedal assembly must be replaced.

REVERSE WARNING BUZZER

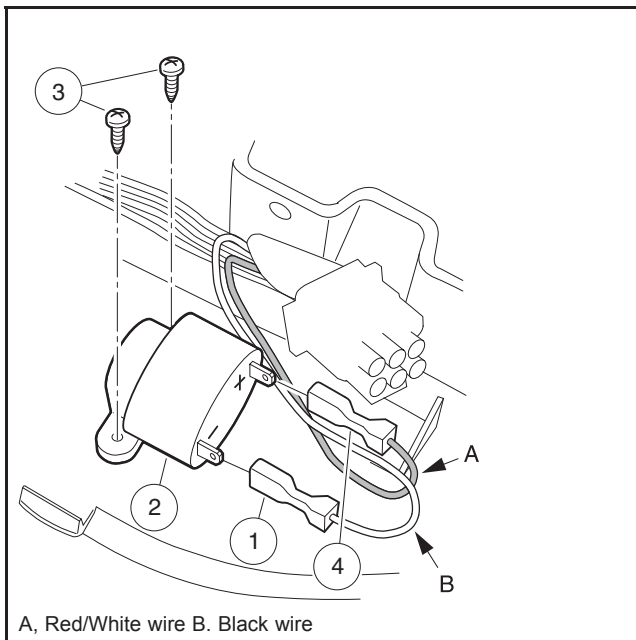
See General Warnings on page 1-2.

TESTING THE REVERSE WARNING BUZZER

See Test Procedure 14 – Multi-Purpose Buzzer and Multi-Purpose Buzzer Limit Switch on page 19-22.

REVERSE WARNING BUZZER REMOVAL

1. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
2. Remove the instrument panel. **See Key Switch Removal on page 20-32.**
3. Disconnect the wires from the reverse warning buzzer (2) **(Figure 27-21, Page 27-24).**
4. Remove the two mounting screws (3) securing the buzzer to the instrument panel.



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Figure 27-21 Reverse Buzzer

REVERSE WARNING BUZZER INSTALLATION

1. Install the screws (3) through the buzzer bracket tabs and tighten to 3.5 in·lb (0.40 N·m) (**Figure 27-21, Page 27-24**).
2. Connect the black wire (1) from the wire harness to the negative (–) terminal on the buzzer.
3. Connect the red/white wire (4) from the wire harness to the positive (+) terminal on the buzzer.
4. Install the instrument panel.
 - 4.1. Connect the electrical connector (3) (**Figure 27-19, Page 27-18**).
 - 4.2. Position the instrument panel (2) on the dash assembly. Make sure tabs on upper edge properly engage with the corresponding slots on the dash assembly. Ensure that there are no wires exposed or pinched during positioning.
 - 4.3. Secure instrument panel to the dash assembly with three screws (1). Tighten screws to 1.8 ft·lb (2.5 N·m).
5. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.
6. Shift the Forward/Reverse handle to the REVERSE position. The buzzer should sound.

REVERSE BUZZER LIMIT SWITCH

See General Warnings on page 1-2.

TESTING THE REVERSE BUZZER LIMIT SWITCH

See Test Procedure 14 – Multi-Purpose Buzzer and Multi-Purpose Buzzer Limit Switch on page 19-22.

REVERSE BUZZER LIMIT SWITCH REMOVAL

1. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
2. Disconnect the wires from the reverse buzzer limit switch (4) located on the back of the Forward/Reverse assembly .
3. Remove the nuts (2) and washers (6) from the neutral lockout limit switch (5) and slide the neutral lockout limit switch off of the screws. Do not disconnect the wires.
4. Remove the spacers (9) from the reverse buzzer limit switch (4) and slide the reverse buzzer limit switch off the screws.

REVERSE BUZZER LIMIT SWITCH INSTALLATION

1. Install the reverse buzzer limit switch (4), and then install two spacers (9) against the limit switch .
2. Install the neutral lockout limit switch (5) with two washers (6) and two nuts (2). Tighten to 5 in·lb (0.6 N·m).
See following CAUTION.

CAUTION

- **Do not overtighten the retaining nuts. If the nuts are over tightened, limit switches could be damaged.**
3. Place the Forward/Reverse handle in REVERSE and make sure that both switches actuate.
 4. Connect the orange wire to the common (COM) terminal and the red/white wire to the normally open (NO) terminal of the reverse buzzer limit switch (4) .
 5. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.
 6. Shift the Forward/Reverse handle to the REVERSE position. The buzzer should sound.

LOW OIL WARNING LIGHT

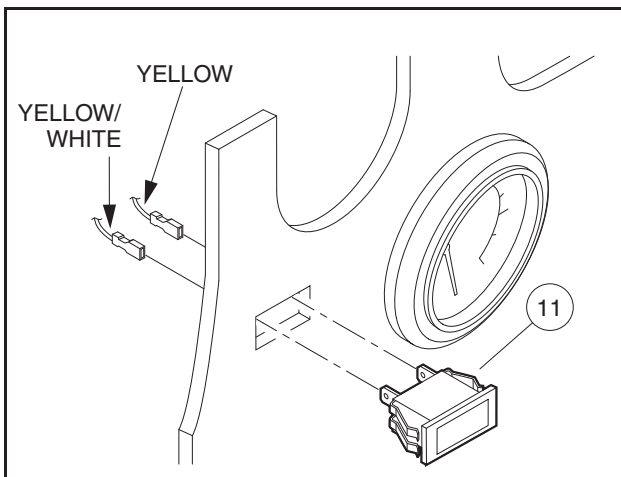
See General Warnings on page 1-2.

TESTING THE LOW OIL WARNING LIGHT

See Test Procedure 16 – Low Oil Warning Light (LED) on page 19-23.

LOW OIL WARNING LIGHT REMOVAL

1. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
2. Remove the instrument panel. **See Key Switch Removal on page 20-32.**
3. Disconnect the wires from the low oil warning light (11) (**Figure 27-22, Page 27-26**).
4. Press the retaining tabs and remove the low oil warning light from the instrument panel.



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Figure 27-22 Low Oil Warning Light

LOW OIL WARNING LIGHT INSTALLATION

1. Push a new unit into hole in instrument panel until plastic tabs engage (**Figure 27-22, Page 27-26**).
2. Connect yellow and yellow/white wires from the wire harness to the low oil warning light.
3. Install the instrument panel.
 - 3.1. Connect the electrical connector (3) (**Figure 27-19, Page 27-18**).
 - 3.2. Position the instrument panel (2) on the dash assembly. Make sure tabs on upper edge properly engage with the corresponding slots on the dash assembly. Ensure that there are no wires exposed or pinched during positioning.
 - 3.3. Secure instrument panel to the dash assembly with three screws (1). Tighten screws to 1.8 ft·lb (2.5 N·m).
4. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.

FUEL GAUGE

See General Warnings on page 1-2.

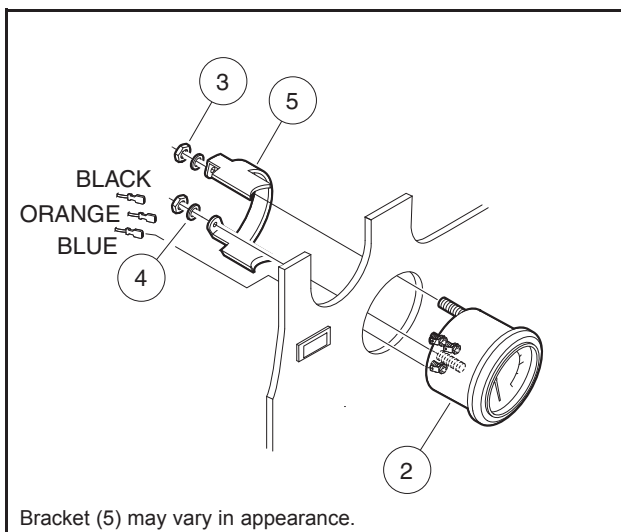
With the key switch in the OFF position, the fuel gauge reads empty. When the key switch is turned to ON, the fuel gauge becomes active.

TESTING THE FUEL GAUGE

See Test Procedure 22 – Fuel Gauge on page 26-36.

FUEL GAUGE REMOVAL

1. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
2. Remove the instrument panel. **See Key Switch Removal on page 20-32.**
3. Disconnect the three wires from the fuel gauge (**Figure 27-23, Page 27-27**).
4. Remove the two hex nuts (3) and lock washers (4) from the threaded studs on the back of the gauge (2). Remove the mounting bracket (5) from the back side of the fuel gauge and remove the gauge from the instrument panel.



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Figure 27-23 Fuel Gauge Installation

FUEL GAUGE INSTALLATION

1. Install a new fuel gauge into hole in instrument panel until flange seats against panel (**Figure 27-23, Page 27-27**).
2. Slide the mounting bracket (5) onto the two threaded studs on the fuel gauge and secure with two lock washers (4) and two hex nuts (3). Tighten to 2.5 in·lb (0.28 N·m). Place one drop of Loctite® on each hex nut. Do not allow Loctite® to come into contact with the fuel gauge casing.
3. Connect the blue wire from the wire harness to the (I) terminal, the orange wire from the wire harness to the (S) terminal, and the black wire from the wire harness to the (G) terminal. **See Sonic Weld and Diode Locations on page 26-10.**
4. Install the instrument panel.
 - 4.1. Connect the electrical connector (3) (**Figure 27-19, Page 27-18**).

- 4.2. Position the instrument panel (2) on the dash assembly. Make sure tabs on upper edge properly engage with the corresponding slots on the dash assembly. Ensure that there are no wires exposed or pinched during positioning.
- 4.3. Secure instrument panel to the dash assembly with three screws (1). Tighten screws to 22 in·lb (2.5 N·m).
5. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.

FUEL LEVEL SENDING UNIT

See General Warnings on page 1-2.

The fuel level sending unit is an integral part of the fuel pump module and is not replaceable. Thoroughly test the fuel level sending unit before replacing the fuel pump module.

TESTING THE FUEL LEVEL SENDING UNIT

See Test Procedure 19 – Fuel Level Sending Unit on page 19-27.

HOURLY METER

See General Warnings on page 1-2.

The hour meter displays the number of hours of use in increments of 0.1 hour.

TESTING THE HOURLY METER

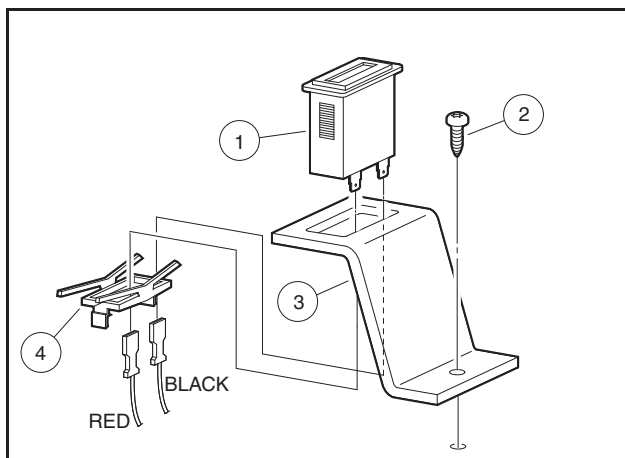
See Test Procedure 23 – Hour Meter on page 26-37.

HOURLY METER REMOVAL

1. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
2. Disconnect the wires from the hour meter (1) (**Figure 27-24, Page 27-29**).
3. Remove screw (2) to release bracket (3).
4. Remove keeper (4) from hour meter to release meter (1) from bracket (3).

HOURLY METER INSTALLATION

1. Install a new hour meter into bracket (3) and secure it by sliding the keeper (4) onto it (**Figure 27-24, Page 27-29**).
2. Connect wires to the hour meter.
3. Position bracket (3) on the vehicle and secure in place with screw (2).



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Figure 27-24 Hour Meter Installation

OIL LEVEL SENSOR

See General Warnings on page 1-2.

TESTING THE OIL LEVEL SENSOR

See Test Procedure 18 – Oil Level Sensor on page 26-33.

OIL LEVEL SENSOR REMOVAL

See Oil Level Sensor Removal on page 28-12.

OIL LEVEL SENSOR INSTALLATION

See Oil Level Sensor Installation on page 28-13.

BATTERY

⚠ DANGER

- Due to the danger of an exploding battery, wear a full face shield and rubber gloves when working on or near batteries.
- Battery – Explosive gases! Do not smoke. Keep sparks and flames away from the vehicle and service area. Ventilate when charging or operating vehicle in an enclosed area. Wear a full face shield and rubber gloves when working on or near batteries.
- Tools, wires, and metal objects can cause sparks when shorted across a battery.
- Follow all instructions carefully when working with batteries.
- Charge battery in a well-ventilated area only.
- Battery – Poison! Contains acid! Causes severe burns. Avoid contact with skin, eyes, or clothing. Antidotes:
 - External: Flush with water. Call a physician immediately.
 - Internal: Drink large quantities of milk or water followed with milk of magnesia or vegetable oil. Call a physician immediately.
 - Eyes: Flush with water for 15 minutes. Call a physician immediately.

⚠ WARNING

- Do not jump start a dead battery using another battery and jumper cables.

GENERAL INFORMATION

See preceding DANGER and WARNING statements.

Gasoline vehicles are equipped with a 12-volt battery. When changing a 12-volt battery in any gasoline-powered vehicle, the same size battery with adequate amperage ratings should be used as a replacement.

A group 26 battery, with a 525 cold cranking amp rating and a reserve capacity of at least 85 minutes is recommended. The group 26 classification indicates battery size: 8 inches W x 6-3/4 inches D x 7 inches H (20.3 cm W x 17.2 cm D x 17.8 cm H). It is important to use the proper size to ensure that the battery clamp will fit correctly.

TESTING THE BATTERY

See Test Procedure 1 – Battery on page 19-9.

See Test Procedure 17 – Battery Test (Under Load) on page 19-24.

PREVENTIVE MAINTENANCE

1. To keep the battery in good operating condition, remove any corrosion immediately. Post connections should be clean and tight. Any frayed or worn wires should be replaced. After all cables have been connected and properly tightened to 41 in·lb (4.3 N·m), coat terminals with Battery Terminal Protector Spray to prevent future corrosion. See preceding WARNINGS and following CAUTION.

⚠ CAUTION

- If battery wire terminals are damaged or corroded, replace or clean them as necessary. Failure to do so may cause them to overheat during operation and could result in a fire, property damage, or personal injury.
2. The battery should be kept clean and dry to prevent self-discharge. Any dirt, grime or acid spillage should be removed. Wash the battery with a bristle brush using water and bicarbonate of soda (1 cup (237 mL) baking soda per 1 gallon (3.8 L) of water). Rinse with water. Do not allow solution to enter battery through the vent cap holes. **See Self-Discharge on page 20-2.**
 3. Check battery periodically to see that it is in a full state of charge. **See Charging the Battery on page 20-3.**
 4. Keep battery hold-down clamp tight. **See Vibration Damage on page 20-2.**

SELF-DISCHARGE

Dirt and battery acid can provide a path for a small current draw that slowly discharges the battery. To prevent self-discharge, the battery should always be kept clean.

Hot weather also has an effect on a battery's self-discharge rate. The higher the temperature, the quicker a battery will discharge. In hotter climates, therefore, the battery should be checked more often. When storing the battery, keep in a cool place. **See Battery Storage on page 20-4.**

VIBRATION DAMAGE

The battery hold-down clamp should always be tight enough to keep the battery from bouncing. Battery life may be severely shortened if the clamp is too loose. Excessive vibration shortens the life of the battery. It may also cause acid to leak out of the vent caps and corrosion to build up on surrounding metal parts. The acid that is lost reduces the capacity of the battery and cannot be replaced.

BATTERY REMOVAL

Also see **DANGER** at beginning of Battery topic.

1. Turn the key switch OFF and remove the key. Place the Forward/Reverse handle in the NEUTRAL position. Chock the wheels.
2. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. Remove the battery hold-down clamp from the battery.
4. Lift the battery from the vehicle. **See following WARNING.**

WARNING

- Keep the battery in an upright position to prevent electrolyte leakage. Tipping the battery beyond a 45° angle in any direction can allow a small amount of electrolyte to leak out of the vent hole. Do not exceed this 45° angle when lifting, carrying or installing battery. The battery acid could cause severe personal injury when accidentally coming in contact with the skin or eyes, and could damage clothing.

CHARGING THE BATTERY

Also see **DANGER** at beginning of Battery topic.

1. Charge the battery using an automotive type 12-volt battery charger. Follow all warnings and procedures supplied by the battery charger manufacturer.
2. Attach the positive (+) charger cable to the positive (+) battery post.
3. Attach the negative (–) charger cable to the negative (–) battery post.
4. The battery may be charged with a slow charge (3 to 10 amps) or a fast charge (20 to 30 amps). Charge until the battery voltage is greater than 12.4 volts. **See following WARNING.**

WARNING

- If the battery case feels hot (approximately 125 °F (52 °C) or more), emits gases, or fluid boils from vents, stop charging immediately. Failure to stop charging battery when any of these conditions are present could result in an explosion, personal injury and/or damage to the battery.
- Do not disconnect the charger DC leads from the battery when the charger is on. The resulting arcing between the DC leads and battery post could cause an explosion.
- If the charger must be stopped, disconnect the AC supply cord from the wall outlet before disconnecting the DC leads from the battery. Allow the battery to cool to room temperature and resume charging battery at a lower amp rate.

BATTERY INSTALLATION

Also see **DANGER** at beginning of Battery topic.

1. Place the battery into the vehicle battery location.
2. Secure the battery to the vehicle with the clamp and install bolt, washer and locknut and tighten to 41 in·lb (4.3 N·m). A loose battery clamp may allow the battery to become damaged from vibration or jarring.
3. Connect battery and spark plug wire(s). **See Connect the Battery - Gasoline Vehicles on page 1-4.**

BATTERY STORAGE

Also see **DANGER** at beginning of Battery topic.

1. Keep the battery clean and free of corrosion. **See Preventive Maintenance on page 20-2.**
2. The battery cables should be disconnected from the battery so the battery can be connected to the charger. The battery can be left in the vehicle. Disconnect the negative (–) cable first. **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
3. Fully charge the battery prior to storage.
4. Store in a cool, dry area. The colder the area in which the battery is stored, the less the battery will self-discharge. A battery stored at 0 °F (-17.8 °C) will discharge very little over a four-month period. A battery stored at 80 °F (27 °C) will have to be recharged every few weeks.
5. Check the state of charge periodically. A battery that is discharged and left in a cold environment can freeze and crack. If the voltage drops below 12.4 volts, the battery should be recharged. **See following WARNING.**

⚠ WARNING

- If the battery is frozen or the container is bulged, discard battery. A frozen battery can explode.
6. The frequency of recharging required depends on the temperature of the storage area, but it is recommended that the battery be monitored for state of charge every month. Also, if the storage area is unheated in a cold climate and recharging is required, it is recommended that the area be heated to at least 60 °F (16 °C) prior to charging. The battery will not charge effectively in cold temperatures for the same reasons that it does not discharge as rapidly in cold temperatures.

CHARGING A DEAD BATTERY

Also see **DANGER** at beginning of Battery topic.

The vehicle is equipped with a starter/generator. The generator is not designed to charge a dead battery. If the vehicle battery has become discharged, it must be charged using a properly rated automotive type charger. **See following WARNING.**

⚠ WARNING

- Do not jump-start a dead battery using another battery and jumper cables.

GROUND CABLES

NOTE: Verify that all cables (fuel tank, engine, battery, starter/generator and voltage regulator) are connected securely.

TESTING THE GROUND CABLES

See Test Procedure 3 – Ground Cables on page 19-11.

Pagination Page

DANGER

- See General Warnings on page 1-2.

WARNING

- See General Warnings on page 1-2.

GENERAL INFORMATION

See General Warnings on page 1-2.

This vehicle is powered by a Subaru EX-40, high-compression, chain driven, overhead cam engine. The engine offers a heavy-duty construction featuring cast iron cylinder liner for longer life, dual ball bearing crankshaft support, low oil level sensor and heavy-duty air cleaner system, to name a few characteristics. **See following NOTE.**

NOTE: Engine rotation is counterclockwise as viewed from the clutch side of the engine.

This section contains information for removing and replacing the engine. For complete instruction on engine disassembly, repair, rebuilding, and reassembly, see your authorized dealer.

Test cylinder compression using a standard compression tester. Low compression would normally indicate a problem in the cylinder assembly such as defective rings, gaskets, etc. Compression should be:

At a normal cranking speed of 1050 to 1100 RPM, the compression should typically be approximately 167 psig (1151 kPa). This value could vary slightly depending on wear of components affecting compression.

See the Subaru EX-40 Engine Repair and Rebuild Manual for complete teardown, rebuild and repair information.

BEFORE SERVICING

Carefully read the applicable information and instructions before beginning engine service. Diagrams, DANGER, WARNING, CAUTION and NOTE statements and detailed descriptions have been included wherever necessary. Anyone attempting engine service should have knowledge and experience in small engine service and repair.

ENGINE ROTATION

When turning the crankshaft by hand, always turn it counterclockwise as viewed from the clutch side of the engine.

TORQUE SPECIFICATIONS

| ITEM | SIZE | TORQUE | |
|---|-------------------------------|--|--|
| Flywheel retaining nut | M18 | 80 ft·lb (110 N·m) | |
| Crankcase cover to block bolts | M8 | 250 in·lb (28.3 N·m) | |
| Cylinder head bolts | M10 | 1st Step New head and bolts: 159 in·lb (18 N·m) | 2nd Step New head and bolts: 336 in·lb (38 N·m) |
| | | Used head and bolts: 159 in·lb (18 N·m) | Used head and bolts: 265 in·lb (30 N·m) |
| | M8 | 159 in·lb (18 N·m) | 2 nd step not needed |
| Connecting rod bolts | M8 | 221 in·lb (25 N·m) | |
| Spark plug | 13/16 in. (21 mm) plug socket | New: 120 in·lb (13.5 N·m) | |
| | | Re-tightening: 216 in·lb (24.5 N·m) | |
| Exhaust flange nuts | M8 | 177 in·lb (20 N·m) | |
| Ignition coil | M6 | 71 in·lb (8 N·m) | |
| Oil sensor | M6 | 80 in·lb (9 N·m) | |
| Oil drain plug | M14 | 18 ft·lb (24.4 N·m) | |
| Fan housing screws | M6 | 90 in·lb (10 N·m) | |
| Fan cover screws | M6 | 25 in·lb (2.8 N·m) | |
| Bolts marked with "4" (when used with nuts) | M8 | 130 in·lb (15 N·m) | |
| | M6 | 50 in·lb (5.9 N·m) | |
| | M5 | 30 in·lb (3.4 N·m) | |

ADJUSTMENTS AND SETTINGS

| ITEM | VALUES |
|---|---|
| Spark plug gap | 0.024 to 0.028 in. (0.6 to 0.7 mm) |
| Valve clearance – Intake & Exhaust (cold) | 0.0047 to 0.0059 in. (0.12 to 0.15 mm) |
| Ignition coil air gap | 0.012 to 0.020 in. (0.3 to 0.5 mm) |
| Compression pressure: | 167 psig (1151 kPa) Allowable Lower Pressure: 120 psig (827 kPa) |

ENGINE OIL – GASOLINE VEHICLE

Even though the low oil warning light on the dash should illuminate if oil level becomes low, engine oil level should be checked monthly. Vehicle should be on a level surface when checking oil. Do not overfill with oil.

Engine Oil Level Check

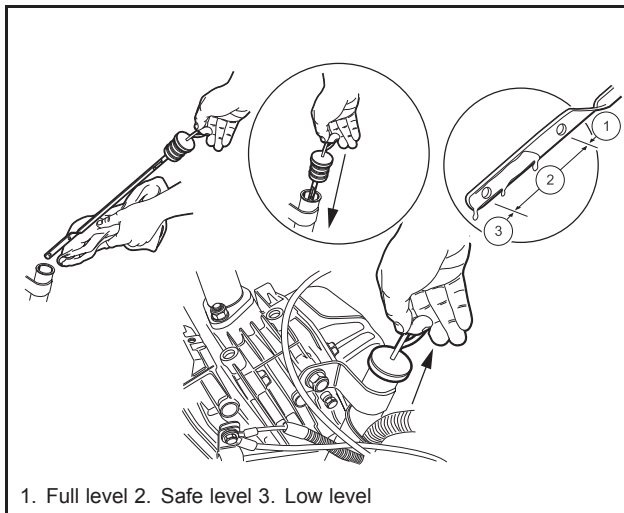
1. Remove the oil level dipstick from the oil filler tube, and wipe oil off dipstick (**Figure 28-1**). **See following CAUTION.**

CAUTION

- Do not remove dipstick while engine is running.

2. Check oil by fully inserting the dipstick into the oil filler tube and immediately removing it.
3. If the oil level is at or below the low level mark on the dipstick gauge, add oil until the level is between low and full levels (safe level).
4. Insert the dipstick into the oil filler tube. **See following NOTE.**

NOTE: Properly recycle or dispose of used oil in accordance with local, state, and federal regulations.



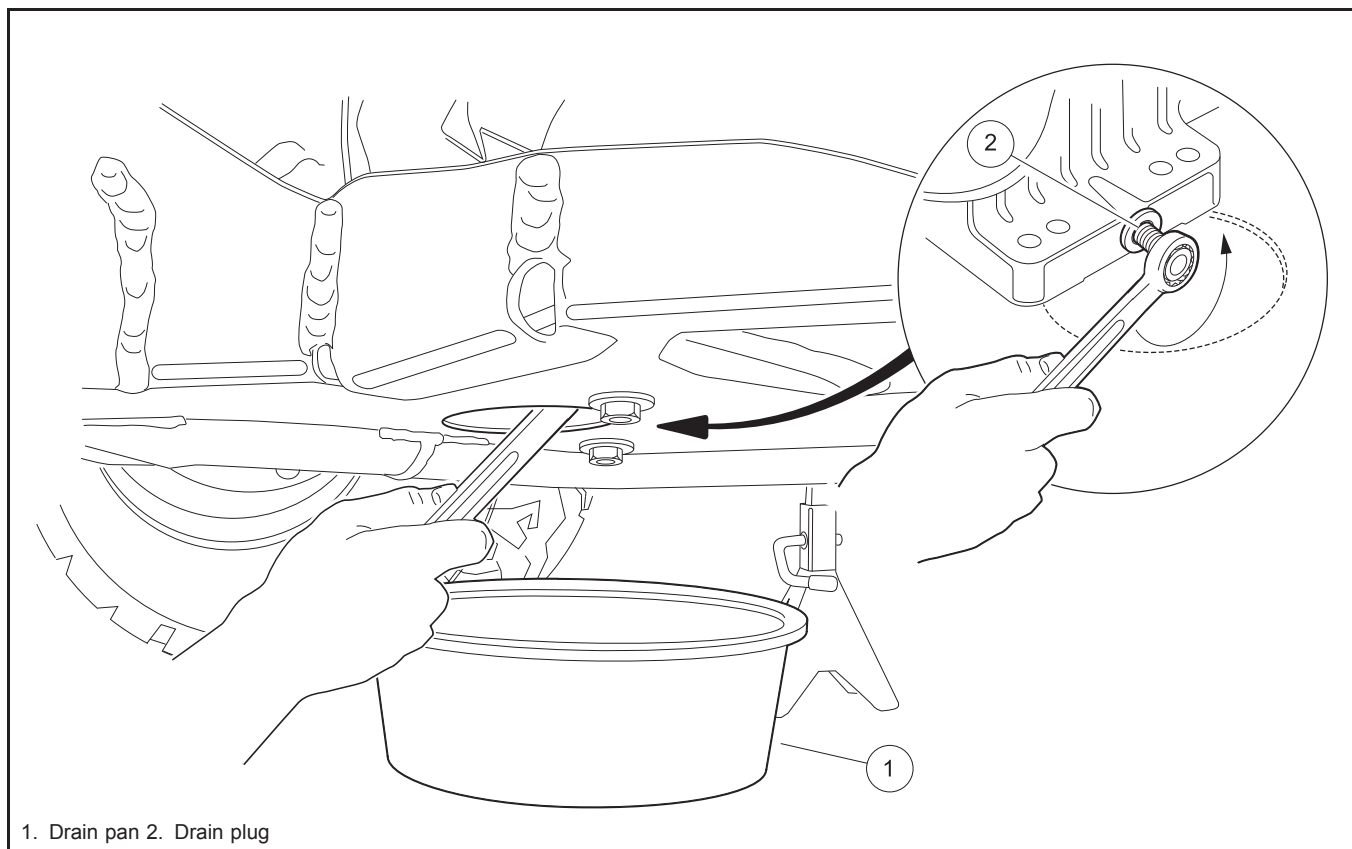
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Figure 28-1 Engine Oil Level Check

Engine Oil Change

Engine oil should be changed after the first 100 hours of operation. After that, it should be changed every 200 hours of operation or annually, whichever comes first.

1. Turn the key switch to the OFF position, then remove the key. Place the Forward/Reverse handle in the NEUTRAL position. Chock the front wheels.
2. Access the engine compartment and place the Maintenance/Operate switch in the MAINTENANCE position.
3. Disconnect battery and spark plug wire.
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
4. Position a pan designed for oil changes under the drain plug (1) (**Figure 28-2**).



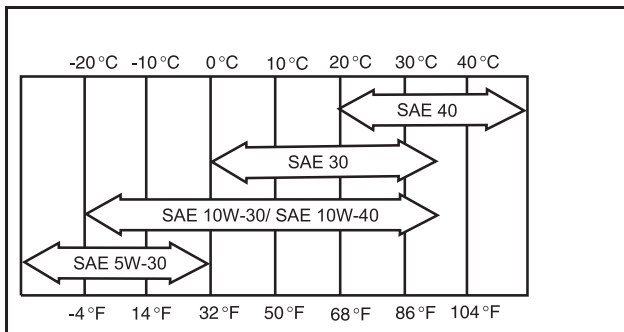
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Figure 28-2 Engine Oil Drain Plug and Pan

5. Use a 14 mm socket or wrench to remove the drain plug, turning it counterclockwise, and allow the engine oil to drain into the pan. **See following WARNING.**

⚠ WARNING

- Do not attempt to change engine oil when the engine is hot or even warm. Engine oil can cause skin burns.
 - Wear safety glasses or approved eye protection when servicing the vehicle. Wear rubber gloves when handling oil drain plug and oil drain pan.
6. Clean the oil drain plug threads with solvent to remove oil and oil residue. Make sure that the compression washer remains on the drain plug.
 7. Use a 14 mm socket or wrench and replace the oil drain plug, turning it clockwise, and tighten to 18 ft·lb (24.4 N·m).
 8. Remove the dipstick and add engine oil into the dipstick port. Use a funnel or pour spout to direct the oil into the dipstick port. The engine requires 40.5 fl-oz (1.2 L) of oil per change. 10W-30 or 5W-30 grade SE or higher is recommended. Refer to oil viscosity guidelines for selection of oil grade (**Figure 28-3**). Replace the dipstick.



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Figure 28-3 Oil Viscosity Chart

9. Connect battery and spark plug wire.
See Connect the Battery - Gasoline Vehicles on page 1-4.
10. With the Forward/Reverse handle in the NEUTRAL position and the Maintenance/Operate switch in the OPERATE position, start and run the engine for a few minutes. Observe the drain plug from under the vehicle and watch for oil leaks. If leaks appear, begin with step 1 and repeat the appropriate steps as needed to correct the problem.
11. Remove the dip stick and check the engine oil as a final step. Replace the dip stick.

SPARK PLUG

Spark plugs are selected to suit specific engine design and vehicle operating conditions. The spark plug is designed to give maximum life and efficient combustion of fuel. The spark gap should be set from 0.024 to 0.028 in. (0.6 to 0.7 mm).

Spark Plug Removal

See General Warnings on page 1-2.

⚠ CAUTION

- Before removal and disassembly, clean the engine.

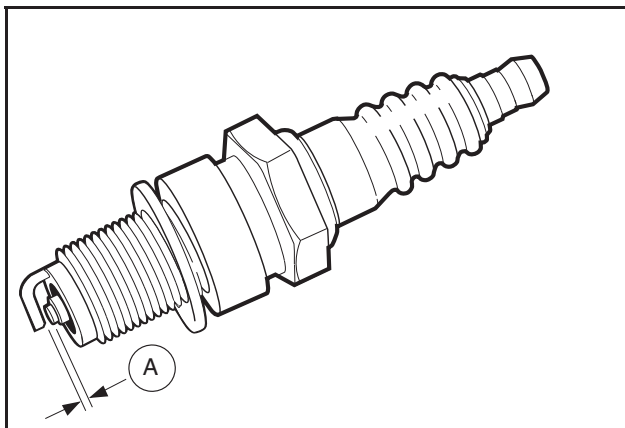
Remove all dirt from plug base in the cylinder head before removing plug. Use a 13/16 in. (21 mm), deep well socket with ratchet or spark plug wrench to loosen the plug.

Spark Plug Cleaning, Inspection and Repair

Examine the plug (**Figure 28-4, Page 28-6**). The deposits on the plug base and electrode are an indication of the correct heat range and efficiency as well as a guide to the general condition of the engine, fuel and air mixture and ignition system. If all of the above conditions are proper, the spark plug should be a light brown color. There should be no bridging between the electrode and base. The electrode should not be eroded. Black color, excessive carbon, and/or a wet plug indicates that the fuel is too rich. White, burned or melted electrodes indicate the fuel is too lean or pre-igniting. Oily deposits on the plug electrode are an indication of worn rings, valve guides, cylinder wall, etc. Also examine the spark plug wire. Remove rubber boot and inspect internal spring for damage. Inspect spark plug wire for damage and be sure spring coil is securely attached to spark plug. **See following WARNING.**

⚠ WARNING

- Remove spark plug wire to avoid accidental start up of the engine when servicing vehicle. To avoid ignition of fuel and serious personal injury or death, never try to start the engine with plug removed from engine.



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Figure 28-4 Spark Plug

Testing the Spark Plug

Check the sparking ability of a cleaned and properly gapped plug on a sparking comparator if possible. Spark should be blue and strong and able to jump a 5/16-in. (8 mm) gap.

Setting the Spark Gap

1. Pass a contact point file between the electrodes to produce flat, parallel surfaces to facilitate accurate gauging.
2. Use a wire type gauge. Bend the outside or ground electrode so only a slight drag on the gauge is felt when passing it between the electrode. Never make an adjustment by bending the center electrode. Set gap (A) from 0.024 to 0.028 in. (0.6 to 0.7 mm) (**Figure 28-4, Page 28-6**).

Spark Plug Installation

NOTE: Before installing the plug, check the condition of the threads in the cylinder head. Soften deposits in cylinder head threads with penetrating oil and clean the threads with a tap if necessary.

Use a high temperature, anti-seize lubricant on the threads of the spark plug to reduce friction when installing a new plug, and reduce "gauling" and thread seizing for future replacements.

Install the spark plug by threading it in until finger tight, then tighten the spark plug to the following torque:

- **New:** 120 in·lb (13.5 N·m).
- **Re-tightening:** 216 in·lb (24.5 N·m).

BREATHER

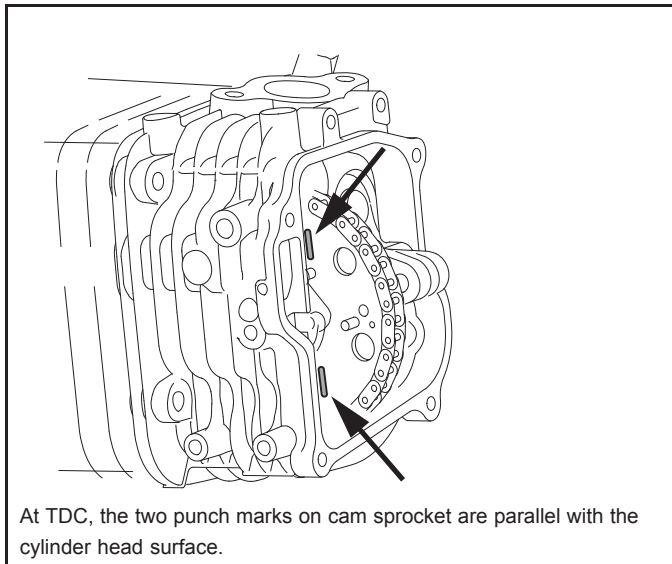
The function of the breather is to create a vacuum in the crankcase which prevents oil from being forced out of the engine through the piston rings, oil seals or gaskets. The breather has a reed valve which limits the direction of air flow caused by the piston moving up and down. Air can flow out of the crankcase, but the one-way reed valve blocks return flow and therefore maintains a vacuum in the crankcase.

Oil laden air in the crankcase passes through the reed valve and expands into the rocker chamber. In the rocker chamber most oil separates from the air and drains back to the crankcase. The air passes through a tube and vents to the intake manifold.

VALVE CLEARANCE CHECK AND ADJUSTMENT

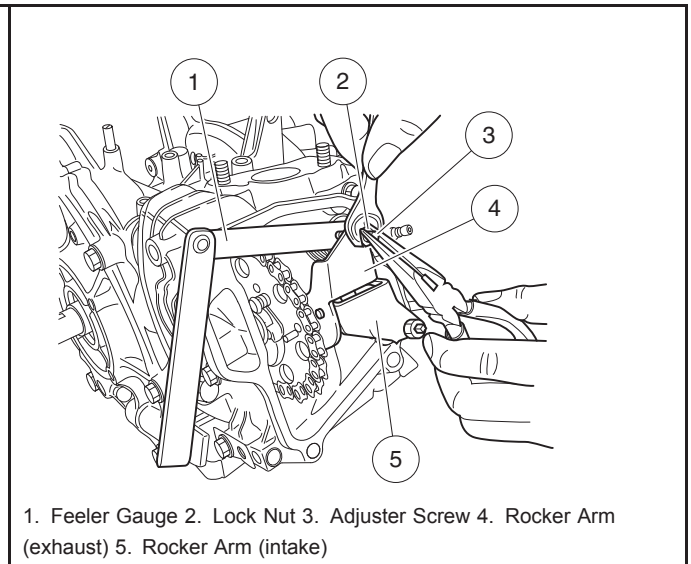
NOTE: Check and adjust clearance when the engine is cold.

1. If equipped, remove air deflector from top of engine.
2. Remove rocker cover.
3. Turn the crankshaft until the piston is at top dead center of the compression stroke (**Figure 28-5, Page 28-7**).
4. Using a feeler gauge (1), measure the clearance between the adjuster screw (3) and the top of the valve stem (**Figure 28-6, Page 28-7**).
5. If necessary, loosen the lock nut (2) and turn the adjuster (3) up or down to adjust the clearance to 0.0047 in. (0.12 mm) for both intake and exhaust. Once clearance is correct, tighten the lock nut (2) to 52 in·lb (6 N·m).
6. After adjusting valve clearances, rotate the crankshaft several full revolutions and verify that the intake and exhaust valve clearance are still correct.



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Figure 28-5 Top Dead Center (TDC) – EX-40 Engine

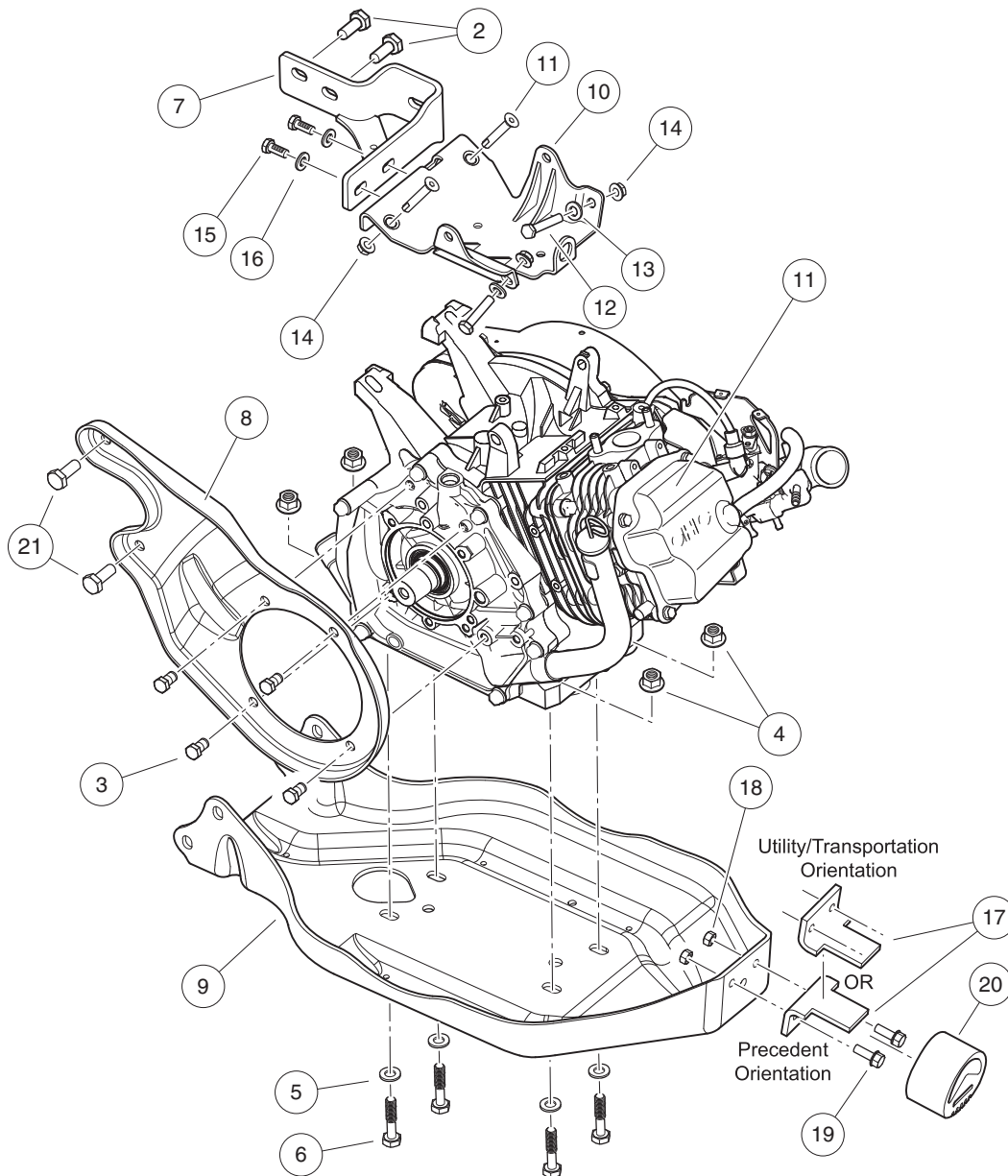


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Figure 28-6 Setting Valve Clearance – EX-40 Engine

ENGINE REMOVAL

ENGINE REMOVAL



3036a

Figure 28-7 EX-40 Engine and Mounting Brackets

⚠ CAUTION

- Before removal and disassembly, clean the engine.

1. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
2. For some vehicles, the engine (1) can be removed by lifting it up and out of the chassis. For other vehicles, it is easier to remove the entire powertrain assembly first. If removing powertrain, **see Transaxle Removal on page 18-10.**
3. If equipped, remove air deflector from top of engine.
4. Disconnect governor cable and P-clamp, air intake hose, fuel line, wire harness connectors, ground cable, and accelerator cable P-clamp. **See Kohler ECH440 - Fuel System, Section 22, Page 22-1.**
5. Remove starter/generator and belt. **See Starter/Generator Removal, Section 20, Page 20-4.**
6. Remove drive clutch. **See Drive Clutch Removal, Section 24, Page 24-5.**
7. Remove muffler. **See Muffler Removal, Section 23, Page 23-1.**
8. Remove engine mounting hardware (2, 3, 4, 5, and 6) from muffler bracket (7), clutch plate (8), and engine pan (9) (**Figure 28-7, Page 28-8**).
9. Lift engine (1) from engine pan (9). **See following NOTE.**

NOTE: The engine weighs approximately 54 lb (24.5 kg).

10. Remove crankcase oil drain plug and drain all oil from crankcase. Dispose of engine oil properly.
11. If replacing engine (1), remove starter/generator mounting weldment (10) and retain for installation on new engine. **See following NOTE.**

NOTE: If replacing engine and throttle body, the ECU must also be replaced. Throttle bodies and ECU's are matched pairs.

ENGINE INSTALLATION

ENGINE INSTALLATION

1. If replacing engine (1), install starter/generator mounting weldment (10) on engine with screws (11), bolts (12), washers (13), and locknuts (14) (**Figure 28-7, Page 28-8**). Tighten locknuts (14) only finger-tight at this time.
2. Install oil drain plug and tighten to 18 ft·lb (24.4 N·m).
3. Place engine (1) onto engine pan (9) and secure with mounting hardware (4, 5, and 6). Leave flange nuts (4) loose at this time.
4. Install clutch plate (8) with bolts (3 and 21). Leave bolts loose at this time.
5. Install bolts (2) through muffler bracket (7) into transaxle but do not tighten.
6. Tighten hardware in the following order:
 - 6.1. Tighten bolts (3) to 27 ft·lb (36 N·m).
 - 6.2. Tighten bolts (21) to 50 ft·lb (68 N·m).
 - 6.3. Tighten bolts (2) to 50 ft·lb (68 N·m).
 - 6.4. Tighten flange nuts (4) to 33 ft·lb (40.6 N·m).
 - 6.5. Tighten locknuts (14) and bolts (15) to 17 ft·lb (23 N·m).
7. Install drive clutch. **See Drive Clutch Installation, Section 24, Page 24-11.**
8. Install muffler. **See Muffler Installation, Section 23, Page 23-2.**
9. Install starter/generator and belt. **See Starter/Generator Installation, Section 20, Page 20-14.**

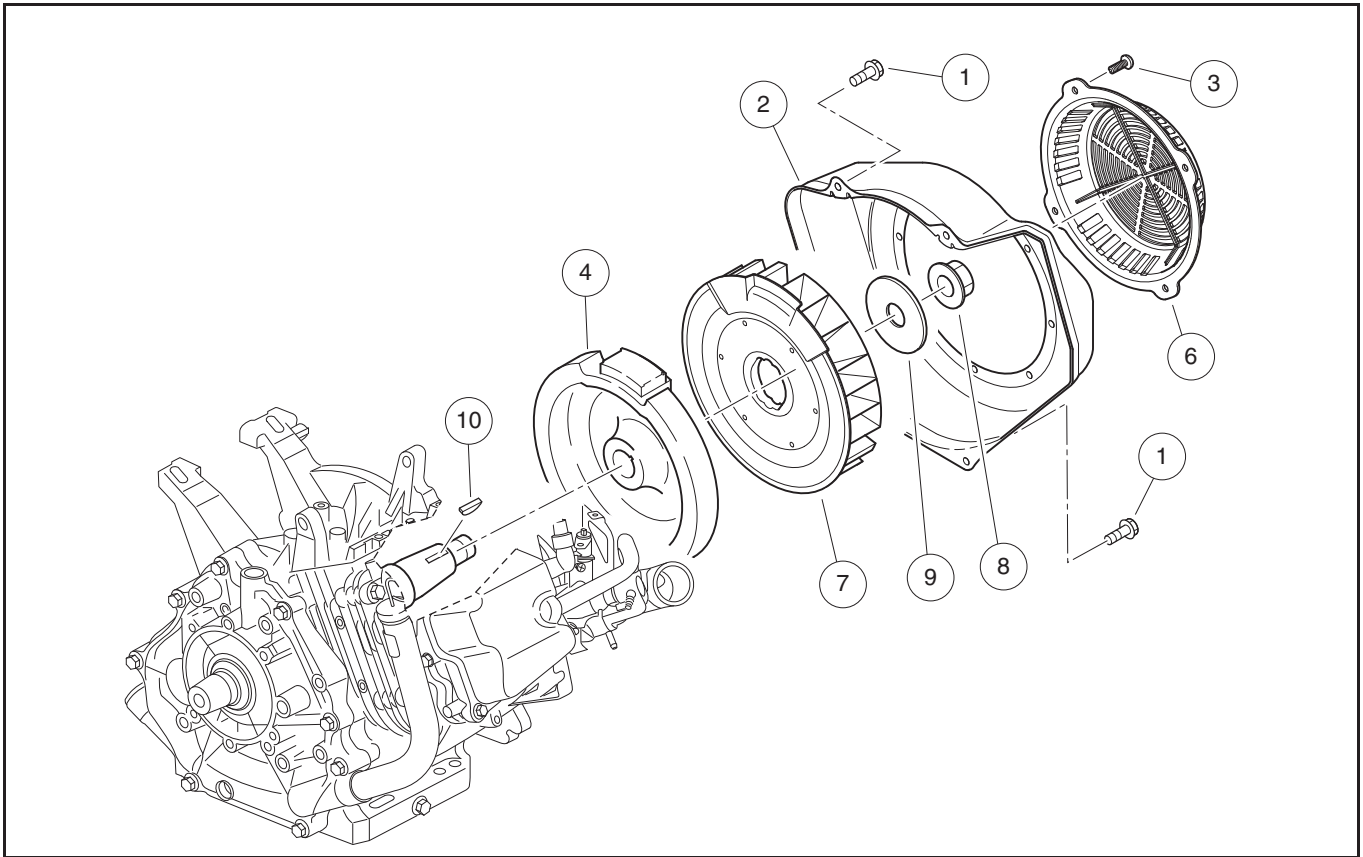
10. If necessary, install powertrain. **See Transaxle Installation, Section 18, Page 18-13.**
11. Connect air intake hose, fuel line, wire harness connectors, ground cable and governor cable. **See Kohler ECH440 - Fuel System, Section 22, Page 22-1.**
12. If equipped, install air deflector on top of engine.
13. Secure accelerator cable and governor cable P-clamps to engine. Tighten P-clamp bolts to 36 in·lb (4.0 N·m).
14. Check all hardware for proper torque/tightness.
15. Fill engine to proper level with correct type of oil. **See Engine Oil – Gasoline Vehicle, Section 28, Page 28-2.**

CAUTION

- Do not overfill with oil.
16. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.
 17. Adjust the engine RPM setting. **See Engine RPM Adjustment on page 22-9.**
 18. Test-drive vehicle to ensure all systems are functional and correctly adjusted.

FLYWHEEL

See General Warnings on page 1-2.



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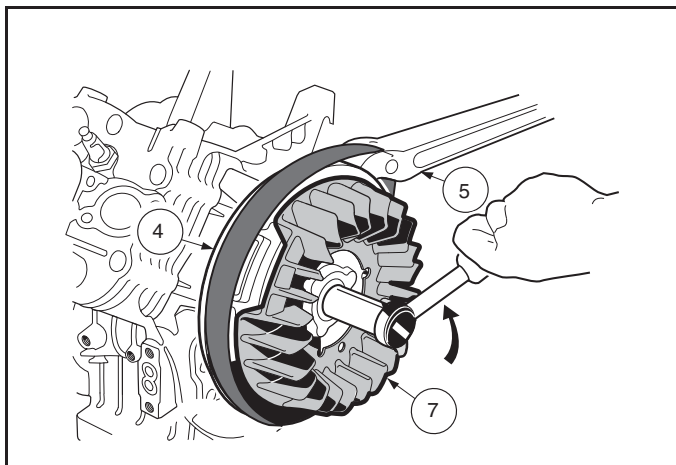
Figure 28-8 Flywheel, Fan and Fan Housing – EX-40

FLYWHEEL REMOVAL

1. Remove screws (1) and fan housing (2) (Figure 28-8, Page 28-11).
2. Hold flywheel (4) only, not fan (7), with strap wrench (5) and use a 24 mm socket to remove flywheel nut (8) and flat washer (9) by turning it counterclockwise (Figure 28-9, Page 28-12). See following CAUTION.

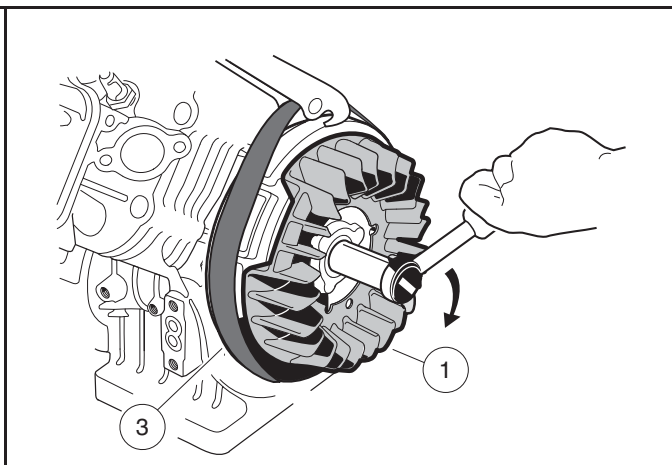
⚠ CAUTION

- The flywheel nut has right-hand threads. Turn it clockwise to tighten, or counterclockwise to loosen.
 - Do not damage the fan blades with the strap wrench. Do not place screwdriver or pry bar in the fan blades.
3. Temporarily install flywheel nut (8) onto end of crankshaft to protect threads and to prevent flywheel (4) from falling off while being pulled.
 4. Detach flywheel (4) from crankshaft with a large, two-jaw puller.
 5. Remove flywheel nut (8) and flywheel (4) from crankshaft.
 6. Remove woodruff key (10) from groove in crankshaft.



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Figure 28-9 Flywheel Nut Removal



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Figure 28-10 Fan and Flywheel Installation

FLYWHEEL INSTALLATION

1. Wipe off any oil on tapered portions of crankshaft and flywheel (4) (Figure 28-8, Page 28-11).
2. Insert woodruff key (10) into keyway of crankshaft. Then align groove in flywheel (4) to woodruff key (10) and push flywheel onto crankshaft until it seats. Install fan (7), flat washer (9), and nut (8) finger-tight.
3. Use a strap wrench (3) to keep flywheel and fan assembly (1) from turning while tightening flywheel nut to 80 ft·lb (110 N·m) (Figure 28-10, Page 28-12). **See following CAUTION.**

⚠ CAUTION

- The flywheel nut has right-hand threads. Turn it clockwise to tighten, or counterclockwise to loosen.
 - Be careful not to damage the fan blades. Use a strap wrench to hold flywheel. Do not place screwdriver or pry bar between fan blades.
4. Install fan housing (2) and tighten screws (1) to 90 in·lb (10 N·m) (Figure 28-8, Page 28-11).

OIL LEVEL SENSOR

TESTING THE OIL LEVEL SENSOR

See Oil Level Sensor on page 26-33.

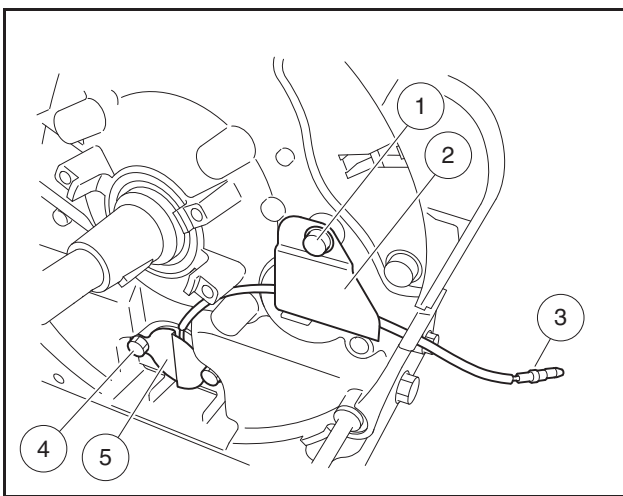
OIL LEVEL SENSOR REMOVAL

1. Drain oil from engine. **See Engine Oil – Gasoline Vehicle, Section 28, Page 28-2.**
2. Remove flywheel. **See Flywheel Removal on page 28-11.**
3. Remove bolt (1) securing oil sensor wire clamp (2) to engine.
4. Disconnect oil level sensor wire (3) from wire harness (Figure 28-11, Page 28-13).
5. Remove two bolts (4) securing oil sensor (5) in engine.

6. Pull oil level sensor (5) out of engine.

OIL LEVEL SENSOR INSTALLATION

1. Lubricate oil level sensor o-ring with oil and carefully insert sensor (5) into engine until fully seated.
2. Secure sensor (5) to engine with two bolts (4) and tighten to 80 in·lb (9 N·m) (**Figure 28-11, Page 28-13**).
3. Connect oil level sensor wire (3) to wire harness.
4. Secure oil sensor wire (3) with clamp (2) and bolt (1). Tighten bolt to 80 in·lb (9 N·m).
5. Install flywheel and fan shroud. **See Ignition Coil Removal on page 28-14.**
6. Fill engine to proper level with correct type of oil. **See Engine Oil – Gasoline Vehicle, Section 28, Page 28-2.**



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Figure 28-11 Oil Level Sensor – EX-40

IGNITION COIL

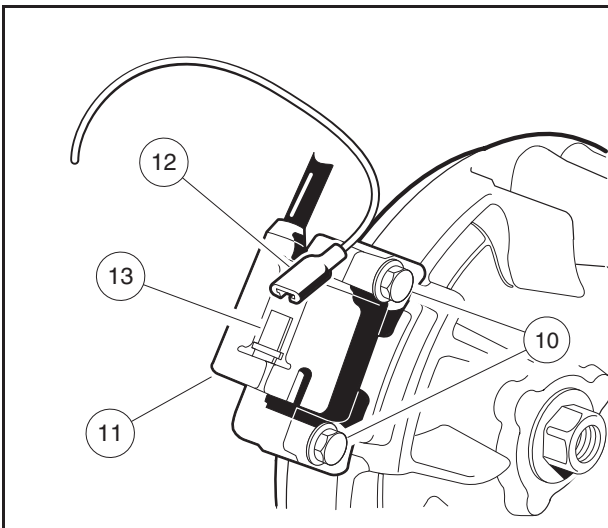
See General Warnings on page 1-2.

TESTING THE IGNITION COIL

See Test Procedure 13 – Ignition Spark on page 19-21 and Test Procedure 15 – Ignition Coil on page 26-31.

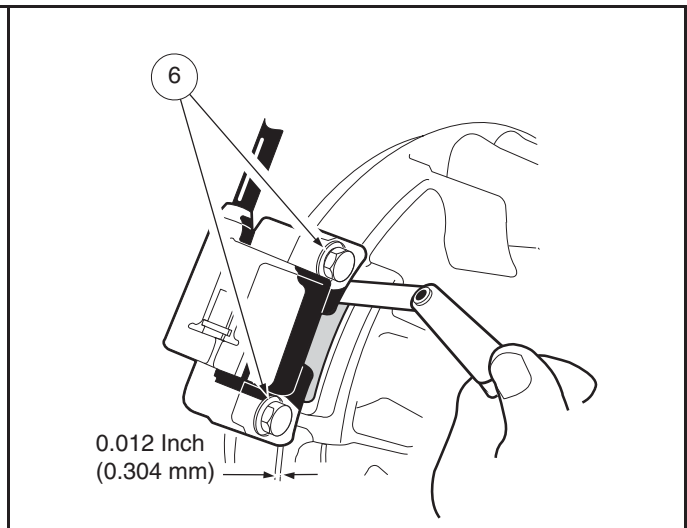
IGNITION COIL REMOVAL

1. Remove screws (1) and fan housing (2) (**Figure 28-8, Page 28-11**).
2. Disconnect ignition coil primary lead wire (12) from spade terminal (13) on ignition coil (11) (**Figure 28-12, Page 28-14**).
3. Remove two bolts (10) and pull ignition coil (11) from engine.



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Figure 28-12 Ignition Coil



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Figure 28-13 Adjust Ignition Coil Air Gap

IGNITION COIL INSTALLATION

1. Position ignition coil (11) onto engine and tighten two mounting bolts (10) finger-tight at this time (**Figure 28-12, Page 28-14**).
2. Rotate flywheel until its magnet is positioned directly under ignition coil (11). Use a bronze feeler gauge to set air gap between ignition coil and flywheel magnet from 0.012 to 0.020 in. (0.3 to 0.5 mm) (**Figure 28-13, Page 28-14**).
3. Tighten ignition coil bolts (6) to 71 in·lb (8 N·m).
4. Connect ignition coil primary lead wire (12) to terminal (13) on coil (**Figure 28-12, Page 28-14**).

SNUBBER

See General Warnings on page 1-2.

NOTE: The snubber is installed on the gasoline vehicle only.

SNUBBER REMOVAL

1. Support the powertrain with a floor jack under the engine pan (1) so that the snubber (2) is raised slightly and does not rest on the vehicle frame (**Figure 28-14, Page 28-15**).
2. Remove the two bolts (3) and two lock nuts (4) securing the snubber bracket (5) to the engine pan (1).
3. Slide snubber (2) and bracket (5) assembly toward battery to remove it from vehicle.
4. Slide snubber (2) off bracket (5).

SNUBBER INSTALLATION

1. Slide snubber (2) onto bracket (5) (**Figure 28-14, Page 28-15**).
2. Install bracket and snubber assembly onto engine pan (1).
3. Tighten lock nuts (4) from 20 to 25 lb·ft (27.1 to 33.9 N·m).

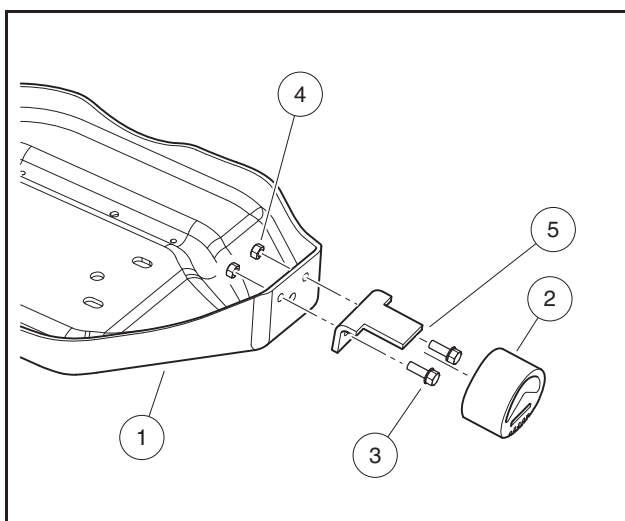


Figure 28-14 Snubber

Pagination Page

⚠ DANGER

- See General Warnings on page 1-2.

⚠ WARNING

- See General Warnings on page 1-2.
- Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure on page 22-11.
- To prevent damage to the ECU, never mix the black and gray connectors that attach to it. The black connector is tethered to the ECU mounting plate to help prevent accidentally installing it in the gray port.

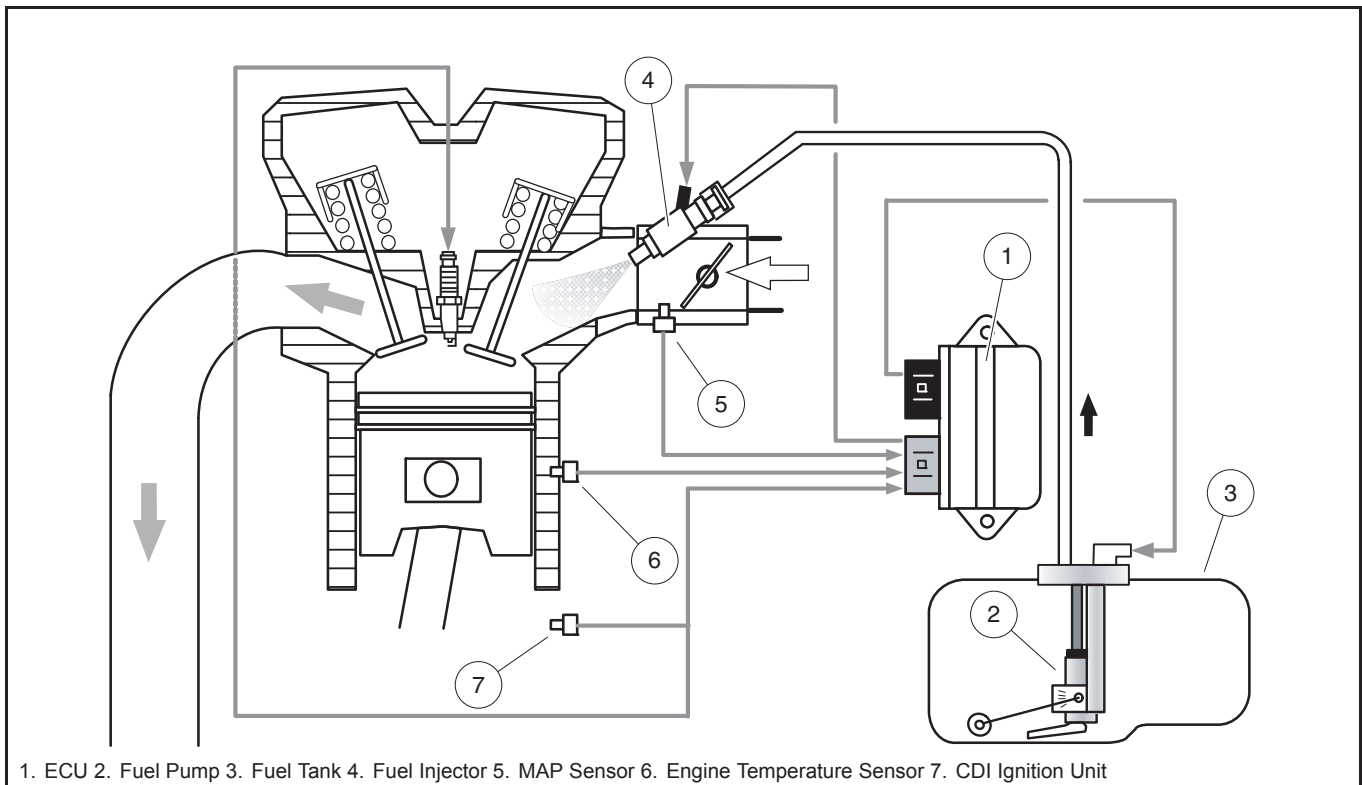
GENERAL INFORMATION

The engine is equipped with a throttle body/fuel injector assembly that is controlled by an ECU and requires no adjustment. The ECU monitors engine conditions through inputs from a Manifold Absolute Pressure (MAP) sensor, engine block temperature sensor and ignition timing.

EFI SYSTEM FEATURES/SPECIFICATIONS

NOTE: This manual covers ECU software version F6i33051.

- The ECU and throttle body/fuel injector assembly are matched pairs and are not available separately
- Fuel pump and low oil warning light operates for a few seconds when key switch is turned to the ON position; it stops if no engine RPM is detected by the ECU
- The ECU blinks fault codes through the Low Oil Warning Lamp
- In-tank fuel pump
- Return-less system
- High fuel pressure system (36 to 38 psig (250 to 260 kPa))
- Controls fuel pump, fuel injector, and oil lamp
- Automatic altitude compensation
- Flow: 16 L per hour minimum @ 12-volts/36 psig (250 kPa)
- Current draw: 2-amps maximum
- Throttle Body Bore: 31 mm diameter
- Open-loop system (i.e. oxygen sensor not used)
- Separate EFI wire harness
- Fail-safe function



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Figure 29-1 EFI System Components

RELIEVING FUEL PRESSURE

In the event that servicing the EFI fuel system necessitates removal of the fuel delivery hose, extreme caution must be exercised. The fuel system is under high pressure even with the engine not running. Disconnecting any part of the fuel delivery system, without first depressurizing the system, will result in a sudden release of pressurized gasoline at the connection. To prevent possible serious injury or death, fuel pressure must be relieved before disconnecting or removing the pump, hose and throttle body.

Either of these suggested procedures **MUST** be followed before attempting ANY service work on the EFI fuel system. Following these will relieve any pressure in the fuel hose prior to opening the fuel system.

TO RELIEVE FUEL PRESSURE

- Shut off engine, disconnect battery, and wait 15 minutes or more to allow pressure to dissipate.
- or –
- Unplug fuel pump module at fuel tank and crank engine for 5 seconds to start reducing fuel pressure. Pause and repeat an additional 5 seconds to allow pressure to dissipate.

NOTE: To absorb any residual fuel that may be present in the fuel hose, place a rag or towel around the hose at the end being disconnected.

THROTTLE BODY

See General Warnings on page 1-2.

Before suspecting the throttle body as the cause of poor engine performance, make sure the fuel and ignition systems are in proper operating condition. Check the following items:

- Spark plug and gap condition. **See Spark Plug on page 28-5.**
- Air filter element. **See Air Filter on page 29-12.**
- Air intake system (for restriction of air flow). **See Air Intake System on page 29-12.**
- Exhaust system (for restrictions). **See Kohler ECH440 - Exhaust System on page 23-1.**
- Fuel pump. **See Fuel Pump Module on page 22-17.**
- Fuel line. **See Fuel Line on page 22-13.**
- Fuel pickup screen or filter. **See Fuel Filter on page 22-24.**

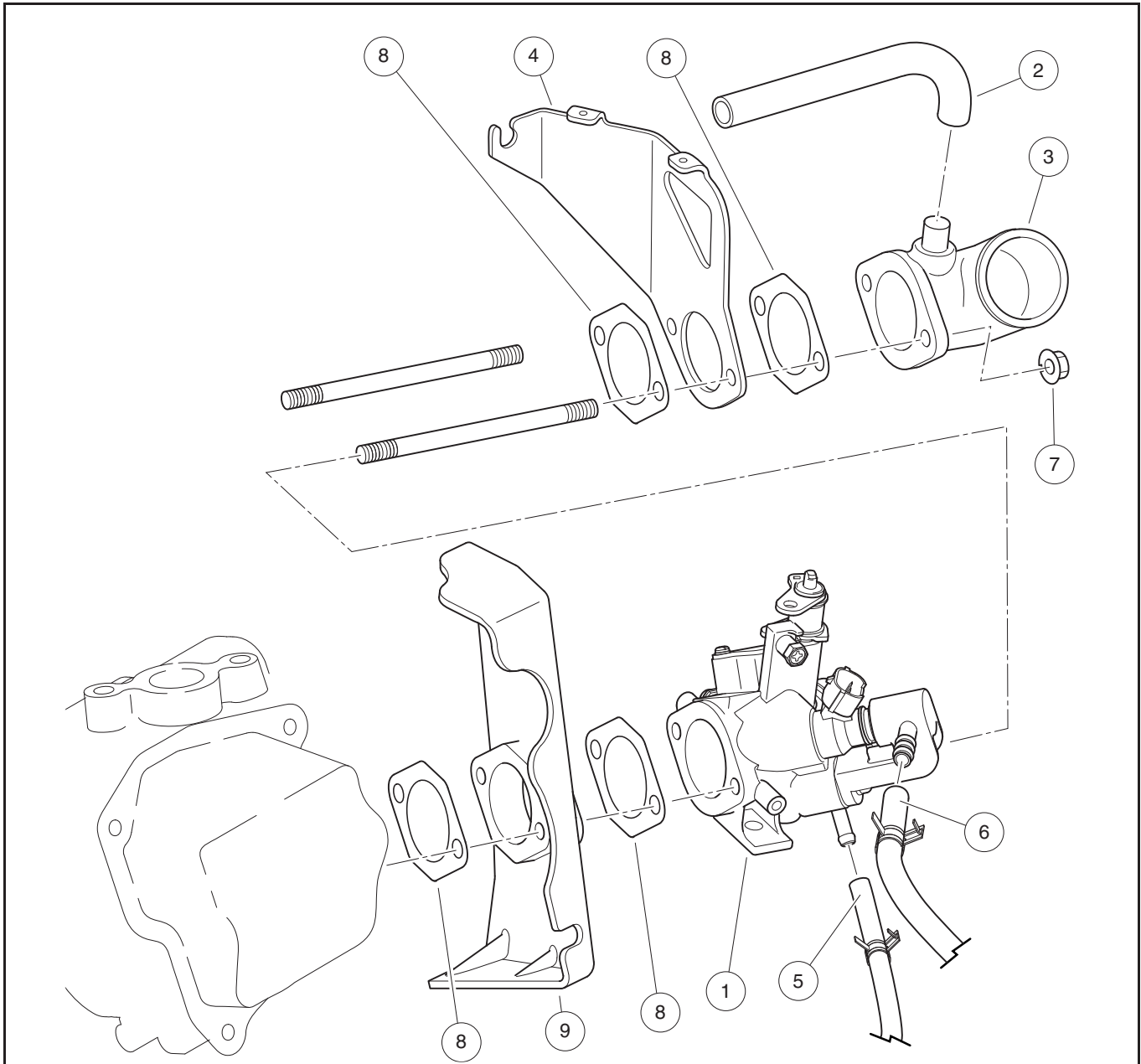
THROTTLE BODY REMOVAL

See General Warnings on page 1-2.

1. Turn the key switch to the OFF position and remove the key, place the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Disconnect battery.
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
3. If equipped, remove air deflector from top of engine.
4. If necessary, remove fuel tank to increase access to the throttle body (1). **See Fuel Tank Removal, Section 22, Page 22-20.**
5. Clean the throttle body (1) and surrounding area (**Figure 29-2, Page 29-4**).
6. Disconnect breather hose (2) from air intake adapter (3).
7. Disconnect governor cable from bracket (4).
8. Disconnect fuel injector and MAP sensor.
9. Remove spring clamps securing fuel line (6) and vent hose (5) to throttle body (1) and disconnect vent hose (5).
10. Disconnect fuel line (6) and drain into an appropriate container. **See following WARNING.** Temporarily plug fuel line to prevent fuel leakage.

⚠ WARNING

- **Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure on page 22-11.**
 - **Carefully drain any fuel into an approved container. Add drained fuel back into fuel tank or dispose of properly.**
11. Loosen air intake hose clamp and disconnect air intake hose.
 12. Remove two flange nuts (7) and slide air intake adapter (3), bracket (4), gaskets (8), insulator (9), and throttle body (1) off threaded studs.



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Figure 29-2 Throttle Body

THROTTLE BODY INSTALLATION

See General Warnings on page 1-2.

1. Install throttle body (1) and its related components onto threaded studs in order as shown (**Figure 29-2, Page 29-4**).
2. Install two flange nuts (7) and tighten to 53 to 71 in·lb (6 to 8 N·m).
3. Connect fuel line (6) and vent hose (5). Secure with spring clamps.
4. Connect fuel injector and MAP sensor.
5. Connect governor cable to bracket (4).
6. Connect breather hose (2) to air intake adapter (3).
7. Connect air intake hose and secure with hose clamp.
8. If removed, install fuel tank. **See Fuel Tank Installation, Section 22, Page 22-22.**
9. If equipped, install air deflector on top of engine.
10. Clean spilled and remove any drained gasoline from the area.
11. Connect battery.
See Connect the Battery - Gasoline Vehicles on page 1-4.
12. Place the Forward/Reverse handle in the NEUTRAL position, chock the wheels, and the neutral lockout switch in the MAINTENANCE position (**Figure 18-1, Page 18-1**).
13. Turn the key switch to the ON position and check for fuel leaks. Repeat as necessary to build fuel pressure. Any leaks found must be fixed.

DANGER

- Repair all fuel leaks before returning the vehicle to service.

14. If no leaks are found, place the neutral lockout switch in the OPERATE position (**Figure 18-1, Page 18-1**).
15. Test drive vehicle to ensure proper operation.

ENGINE CONTROL LINKAGES

See General Warnings on page 1-2.

⚠ DANGER

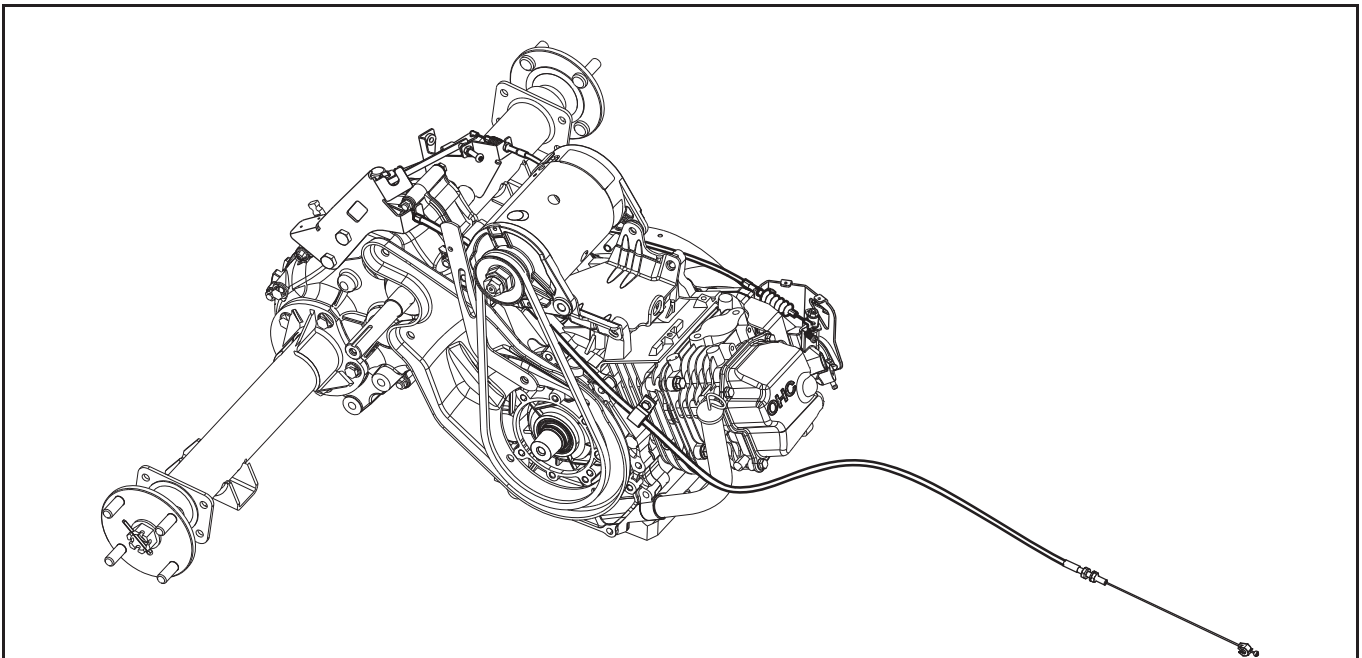
- To ensure the vehicle does not run over you while you disconnect or adjust the accelerator push rod, do the following:
 - Turn key switch OFF and remove key, place Forward/Reverse handle in the NEUTRAL position, and chock the wheels prior to servicing the vehicle.
 - Disconnect battery cables, negative (–) cable first.
 - Disconnect the spark plug wire from the spark plug.
 - See Disconnect the Battery - Gasoline Vehicles on page 1-3.

GENERAL INFORMATION

For proper vehicle operation, it is important the accelerator cable, governor linkage, and throttle adjustments are done correctly and in the proper sequence. **See following CAUTION.**

⚠ CAUTION

- Improper adjustment can result in poor vehicle performance and/or damage to the engine components.



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Figure 29-3 Engine Control Linkages – Gasoline Vehicles

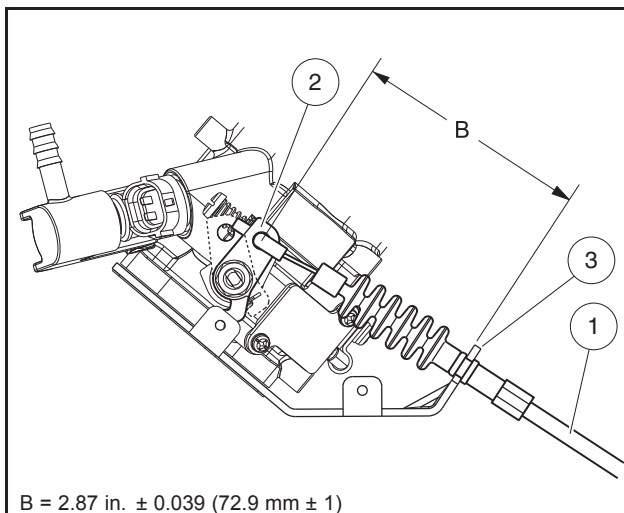
GROUND SPEED

NOTE: If possible, the manufacturer recommends measuring ground speed when setting engine RPM.

This vehicle should reach the forward ground speed specified in **Section 2 – Vehicle Specifications**. See **How to Measure Ground Speed** on page 22-8.

GOVERNOR CABLE

Governor Cable Removal



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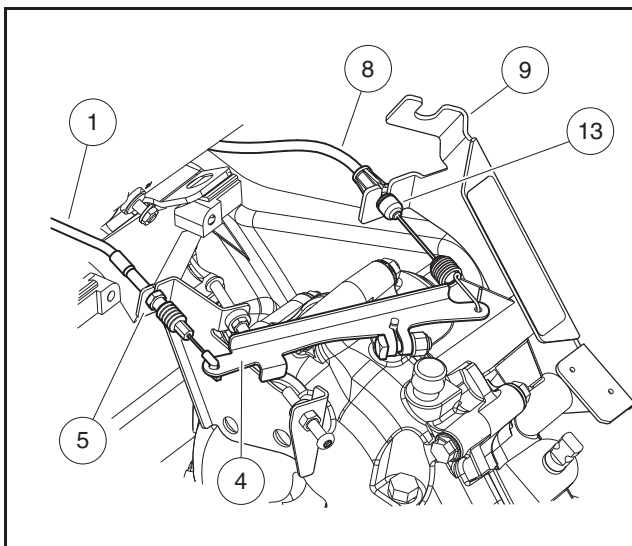
Figure 29-4 Governor Cable At Throttle Body and Power Limiter Screw Gap Adjustment

1. Turn the key switch to the OFF position and remove the key, place the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
3. At engine:
 - 3.1. If equipped, remove air deflector from top of engine.
 - 3.2. Disconnect "Z" fitting of governor cable (1) from throttle lever (2) (**Figure 29-4, Page 29-7**).
 - 3.3. Unsnap governor cable (1) from throttle body bracket (3).
4. At transaxle:
 - 4.1. Disconnect "Z" fitting of governor cable (1) from governor arm (4) (**Figure 29-5, Page 29-8**).
 - 4.2. Loosen jam nuts at governor bracket (5) and remove cable (1) from vehicle.

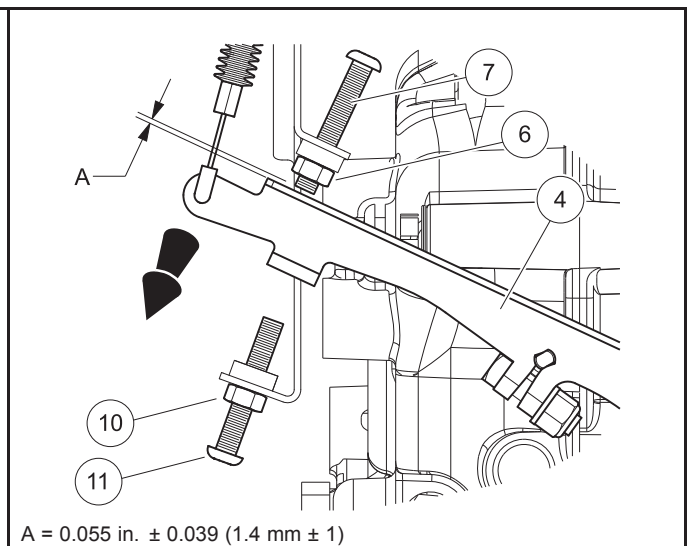
Governor Cable Installation and Adjustment

1. At engine:
 - 1.1. Snap governor cable (1) into throttle body bracket (3) (**Figure 29-4, Page 29-7**).
 - 1.2. Connect "Z" fitting of governor cable (1) to throttle lever (2).
 - 1.3. If equipped, install air deflector on top of engine.
2. At transaxle:
 - 2.1. Slide bellows off threaded end of cable housing, separate jam nuts and place threaded end into governor bracket (5) (**Figure 29-5, Page 29-8**).
 - 2.2. Finger-tighten jam nuts.

- 2.3. Push bellows back onto threaded end of cable housing.
- 2.4. Connect "Z" fitting of governor cable (1) to governor arm (4).
3. Loosen adjustment screw jam nuts (6 and 10) and back off throttle stop screw (7) and power limiter screw (11) several turns (**Figure 29-6, Page 29-8**).
4. Rotate governor arm (4) counterclockwise until it stops and hold in this position (**Figure 29-6, Page 29-8**).
5. Adjust governor cable jam nuts until throttle lever (2) is at "wide open throttle" (WOT) (**Figure 29-4, Page 29-7**) and tighten the governor cable jam nuts to 36 in·lb (4.0 N·m).
6. While still holding this position, adjust power limiter screw (11) (**Figure 29-6, Page 29-8**) to set distance (B) at 2.87 in. (± 0.039) (1.4 mm (± 1)) as shown (**Figure 29-4, Page 29-7**) between throttle lever (2) and throttle body bracket (3). Tighten limiter screw jam nut (10) to 36 in·lb (4.0 N·m).
7. Release governor arm (4) to return to "idle" position.
8. Adjust gap (A) between governor arm (4) and throttle stop screw (7) to 0.055 in. (± 0.039) (1.4 mm (± 1)) as shown (**Figure 29-6, Page 29-8**). Tighten stop screw jam nut (6) to 36 in·lb (4.0 N·m).
9. Check engine RPM adjustment. **See Engine RPM Adjustment on page 22-9.**



3130
Figure 29-5 Governor and Accelerator Cables At Governor Arm



3131
Figure 29-6 Throttle Stop Screw Gap

ACCELERATOR CABLE

Accelerator Cable Removal

1. Turn the key switch to the OFF position and remove the key, place the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
3. At transaxle:
 - 3.1. Unhook spring fitting of accelerator cable (8) from governor arm (4) (**Figure 29-5, Page 29-8**).
 - 3.2. Unsnap accelerator cable (8) from FNR/accelerator cable bracket (9).
4. At pedal group:
 - 4.1. Access the pedal group and disconnect accelerator cable clip from the accelerator pedal. **See Pedal Group Removal on page 5-5.**
 - 4.2. Loosen jam nuts securing accelerator cable to underbody and remove accelerator cable (9) from vehicle.

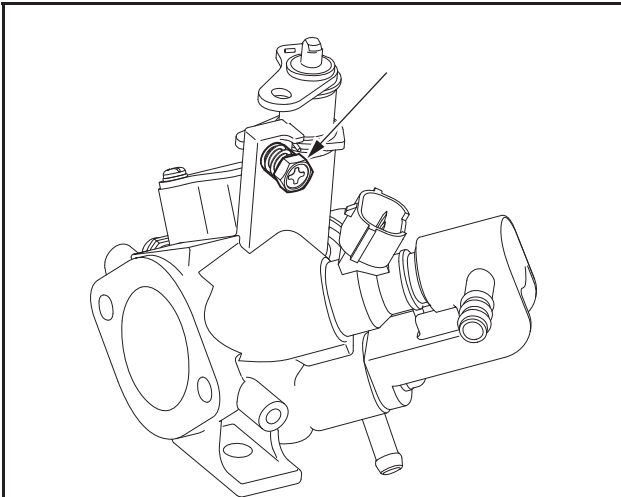
Accelerator Cable Installation

1. At transaxle:
 - 1.1. Hook spring fitting of accelerator cable (8) to governor arm (4) (**Figure 29-5, Page 29-8**).
 - 1.2. Snap accelerator cable (8) into FNR/accelerator cable bracket (9).
 - 1.3. Push dust shield (13) onto end of cable housing.
2. At pedal group:
 - 2.1. Insert the accelerator cable through the hole in the frame and feed it towards the pedal group. Connect the accelerator cable to the pedal group. **See Pedal Group – Gasoline Vehicle on page 5-5.**
 - 2.2. Separate jam nuts (9) on cable and place threaded end into slot in underbody . Tighten jam nuts finger-tight.
 - 2.3. Before tightening the cable jam nuts, make sure the engine RPM adjustment is correct. **See Engine RPM Adjustment on page 22-9.**
3. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.

CLOSED THROTTLE OR IDLE ADJUSTMENT – PEDAL-START VEHICLES

When the accelerator pedal is released, the engine will stop. Therefore, it is not possible to measure or set idling speed under normal vehicle operating conditions. Set throttle valve as follows:

1. Loosen the throttle body idle screw so that it is not touching the throttle lever (**Figure 29-7, Page 29-10**).
2. Slowly tighten the idle screw until it lightly touches the throttle lever, then tighten it an additional 1 whole turn (360 degrees).



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Figure 29-7 Idle Screw

HOW TO MEASURE GROUND SPEED

Best Method

An easy way to check ground speed is by using a GPS device or smartphone application (app). If these are not available, use the alternate method below.

Alternate Method (Calculated)

Ground speed is easily determined by a known distance travelled, divided by the amount of time it took to travel that known distance ($Rate = Distance/Time$).

1. Establish a known distance to travel (example: 100 ft. (30.5 m) in a safe location using cones or other type of marker.
2. Drive vehicle and bring to maximum speed before reaching the first cone.
3. Using a stopwatch, record the amount of time it takes to travel from the first cone to the second cone at maximum speed.
4. With distance and time determined, calculate ground speed:
 - 4.1. **Rate in seconds:** Divide distance (100 ft (30.5 m)) by time (5 seconds) = 20 ft/sec (6.1 m/sec).
 - 4.2. **Convert seconds to hour:** Multiply 20 ft/sec (6.1 m/sec) by 3600 (the number of seconds in an hour) = 72000 ft/hour (21960 m/hour)
 - 4.3. **Convert to MPH:** Divide 72000 ft/hour by 5280 (number of ft in 1 mile) = 13.64 miles/hour
Convert to KPH: Move the decimal point over three places; 21960 m/hour = 21.96 km/hour

ENGINE RPM ADJUSTMENT

⚠ DANGER

- Do not operate gasoline vehicle in an enclosed area without proper ventilation. The engine produces carbon monoxide, which is an odorless, deadly poison.

1. If governor is adjusted, proceed to step 2; otherwise, adjust governor. **See Governor Cable Installation and Adjustment on page 22-3.**
2. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.
3. Measure vehicle ground speed. **See How to Measure Ground Speed on page 22-8.**
4. Compare measured ground speed with forward ground speed specified in **Section 2 – Vehicle Specifications.**
5. If adjustment is necessary, use the following procedures:
 - 5.1. To **reduce** RPM, adjust the two jam nuts (6) to move the accelerator cable housing toward the rear of the vehicle until specified ground speed is reached (**Figure 5-6, Page 5-6**). **See Section 2 – Vehicle Specifications.**
 - 5.2. To **increase** RPM, adjust the two jam nuts to move the accelerator cable housing forward until specified ground speed is reached.
 - 5.3. Be sure both jam nuts are locked against the underbody and check ground speed again. If ground speed needs to be adjusted, repeat previous step. **See following NOTE.**

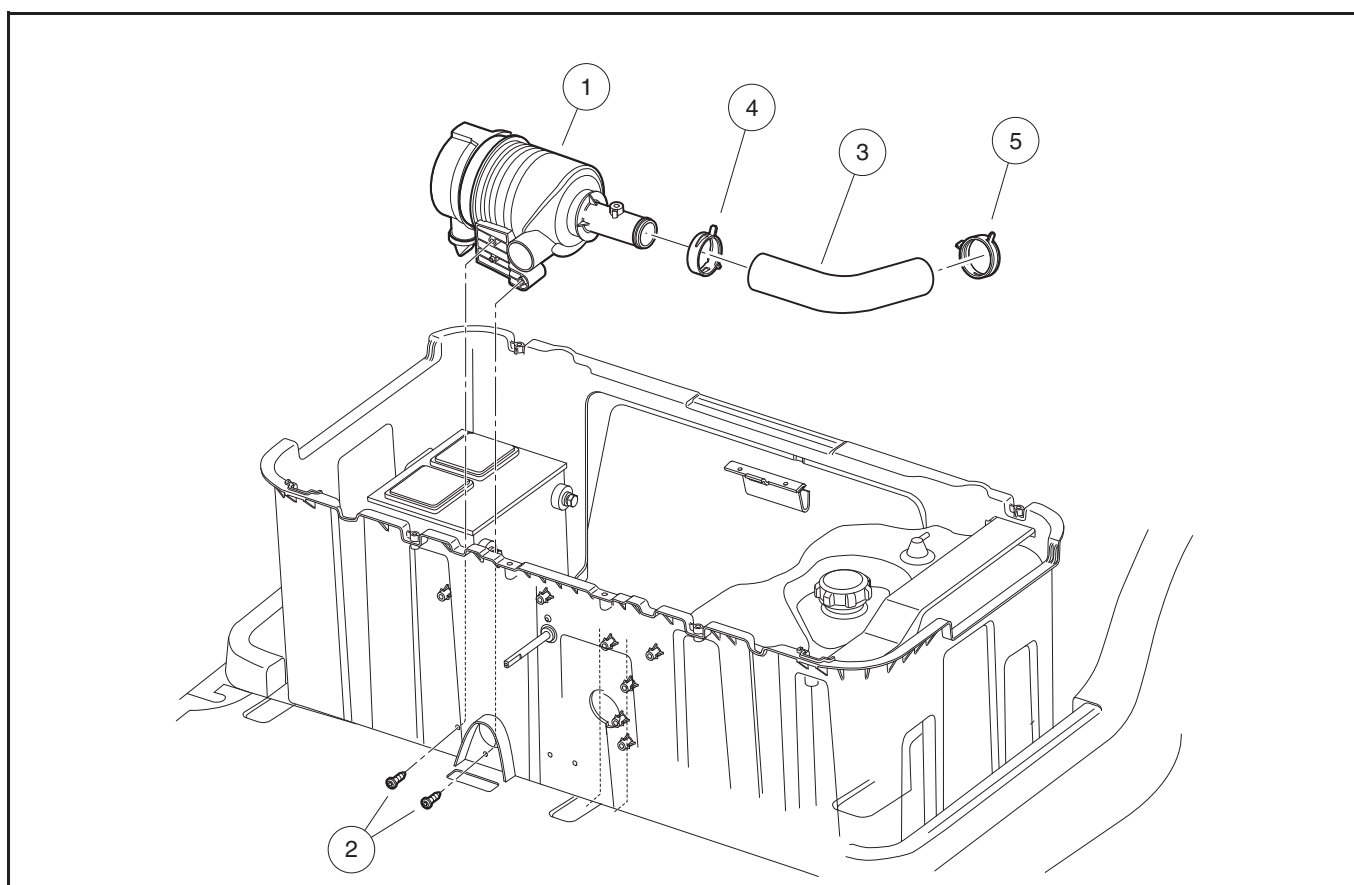
NOTE: If more adjustment is required than the cable housing will allow, make sure the spring fitting on the other end of the accelerator cable is properly installed. Excessive drive belt and clutch wear can also prevent proper ground speed adjustment. Check them for excessive wear. **Section 31 — Subaru EX-40 - Clutches**

AIR INTAKE SYSTEM

See General Warnings on page 1-2.

GENERAL INFORMATION

The air intake system is a simple mechanism requiring very little or no maintenance. The system consists of an air cleaner (1) and air hose (3) mounted under the seat (**Figure 29-8, Page 29-12**). The air cleaner draws clean, cool air from beneath the vehicle via an opening between the kick plate and the fuel bucket. The air passes through the air cleaner and hose to the throttle body.



3124a

Figure 29-8 Air Intake System – Gasoline Vehicle

AIR FILTER

The air filter should be checked every year or 100 hours. More frequent service may be required in extremely dirty operating environments. Need for immediate servicing will be indicated by a loss of power, sluggish acceleration, or an engine which runs roughly with excessive black exhaust smoke.

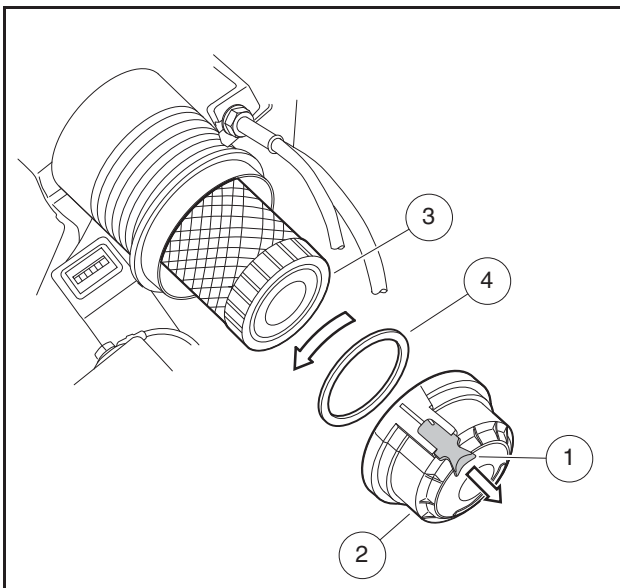
Air Filter Replacement

1. Access the engine compartment.
2. Pull the yellow tab (1) on the air filter cover (2) away from the air cleaner (**Figure 29-9, Page 29-13**).
3. Rotate the cover counterclockwise to approximately the 10 o'clock position to release the internal locking tabs. Remove the cover.

4. Remove the air filter (3) and dispose of properly.
5. Using a clean cloth, wipe away any dust or dirt from inside the air cleaner. Remove all dirt build-up around the inside lip of the air cleaner housing or the cover will not seal properly.
6. Install new air filter, inserting the open end into the air cleaner housing first.
7. Check that the air intake gasket (4) is in place in the cover (2) and oriented correctly with the coated side of the gasket facing toward the air cleaner housing.
8. **Place the cover (2) over the air cleaner housing. Press firmly to engage the seals and rotate the cover clockwise until the yellow tab is at the 11 o'clock position.**
9. Press in the yellow tab (1) to lock the cover on the air cleaner. **See following CAUTION.**

CAUTION

- Engine damage will occur if the air filter cover is not properly secured.
- If air cleaner is extremely dirty, clean thoroughly.
- Use only Club Car replacement air filters or equivalent. The use of other air filters could result in engine damage. If the air filter is too small, the cover will seat before the filter can seal, leaving space for dirt to pass into the engine on all sides of the element. This will damage the engine and void the warranty.



2688

Figure 29-9 Air Filter

AIR INTAKE SYSTEM REMOVAL

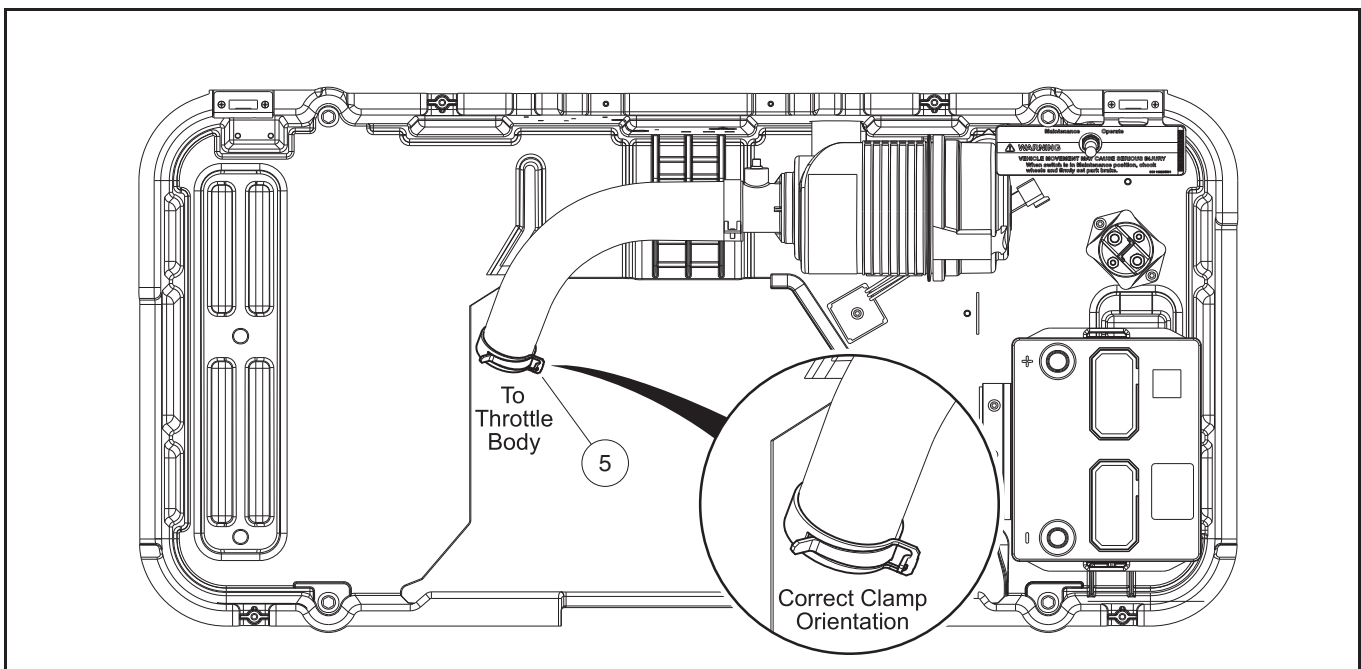
1. Turn the key switch to the OFF position and remove the key, place the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Access the engine compartment.
3. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
4. Hose (3) may be removed by removing the clamps (4 and 5) at the air cleaner (1) and the throttle body (**Figure 29-8, Page 29-12**).

5. The air cleaner (1) is secured to the fuel bucket with screws (2). Access to the screws requires that the kick plate be removed. **See Kick Plate Removal on page 4-18.**

AIR INTAKE SYSTEM INSTALLATION

⚠ WARNING

- Intake hose (3) is made from a special fire retardant neoprene material. Use of any hose that does not meet Club Car, LLC specifications could create a fire hazard.
 - Improper orientation of the hose clamp (5) may result in fuel tank damage (Figure 29-10, Page 29-14).
1. Position air cleaner (1) inside the fuel bucket (Figure 29-8, Page 29-12). Secure with screws (2). Tighten screws to 2.7 ft·lb (3.5 N·m).
 2. Install hose (3) on air cleaner (1) and secure with clamp (4).
 3. Install hose (3) on throttle body and secure with clamp (5) oriented as shown (Figure 29-10, Page 29-14) with tabs up.
 4. Install kick plate. **See Kick Plate Installation on page 4-18.**



3192

Figure 29-10 Hose Clamp Orientation at Throttle Body

FUEL LINE

See General Warnings on page 1-2.

NOTE: This EFI gasoline vehicle is equipped with SAEJ30R9 fuel hose rated for high-pressure systems. Always replace the fuel line on this vehicle with approved Club Car replacement part. Do not attempt to repair, patch or splice the fuel line.

The fuel line must be properly routed from the fuel tank to the throttle body. A small, spring steel band clamp is used on the fuel line connection at the throttle body and must be tight. A plastic, dual-locking connector is used at the fuel tank. **See following WARNING.**

WARNING

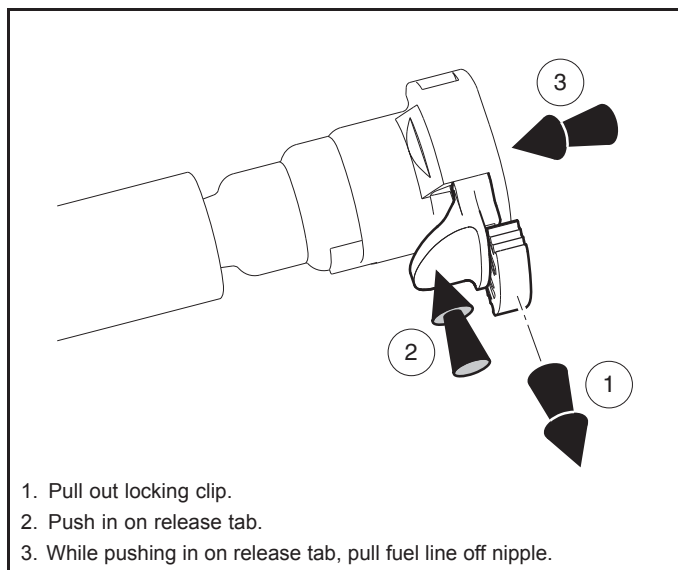
- Make sure fuel line is the correct length and properly routed. Failure to heed this warning could result in damage to fuel line and fire.
- Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure on page 22-11.

FUEL LINE REMOVAL

1. Turn the key switch to the OFF position and remove the key, place the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Disconnect battery.
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
3. Clean the top of the fuel tank and fuel pump module.
4. At engine:
 - 4.1. Remove spring clamp securing fuel line to throttle body.
 - 4.2. Disconnect fuel line and drain into an appropriate container. **See following WARNING.**

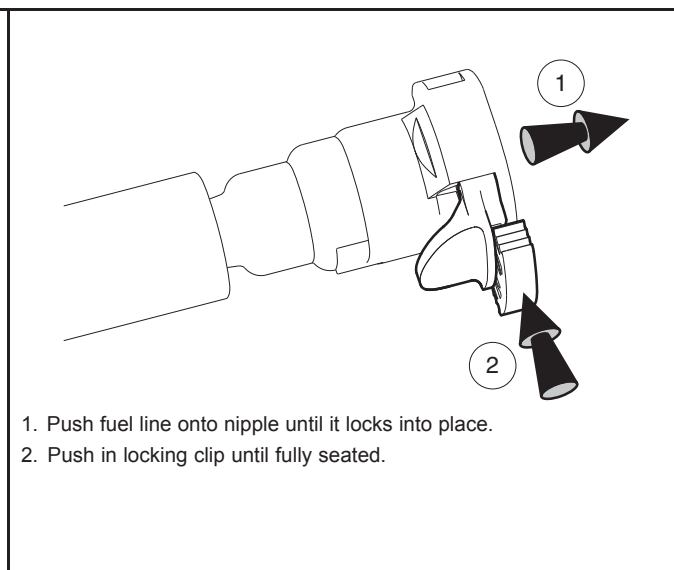
WARNING

- Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure on page 22-11.
 - Carefully drain any fuel into an approved container. Add drained fuel back into fuel tank or dispose of properly.
5. At fuel tank:
 - 5.1. Disengage clip as shown (**Figure 29-11, Page 29-16**).
 - 5.2. Push in tab to unlock connector and pull fuel line from nipple on fuel pump module and remove line from vehicle.



3050

Figure 29-11 Fuel Line Connector – To Disconnect



3051

Figure 29-12 Fuel Line Connector – To Connect

FUEL LINE INSTALLATION

1. At fuel tank:
 - 1.1. Clean the nipple on top of fuel pump module.
 - 1.2. Push fuel line fully onto nipple until it locks in place (**Figure 22-17, Page 22-16**).
 - 1.3. Engage locking clip by pushing in until fully seated and completely prevents the line from being pulled off nipple.
2. At engine:
 - 2.1. Connect fuel line to throttle body and secure with spring clamp. **See following DANGER.**

⚠ DANGER

- Ensure line is connected properly to avoid a leak that can cause a fire.
- Make sure fuel line is the correct length and properly routed. Failure to heed this warning could result in damage to fuel line and fire.

- 2.2. Make sure that the fuel line is routed correctly (**Figure 29-13**).

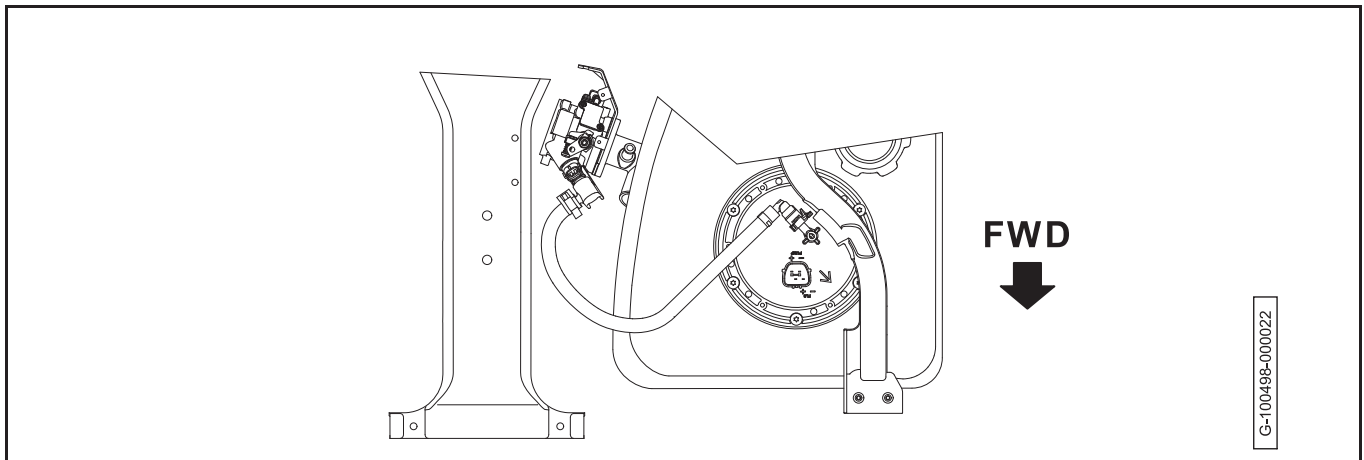


Figure 29-13

3. Clean spilled and remove any drained gasoline from the area.
4. Connect battery.
See Connect the Battery - Gasoline Vehicles on page 1-4.
5. Place the Forward/Reverse handle in the NEUTRAL position, chock the wheels, and the neutral lockout switch in the MAINTENANCE position (**Figure 18-1, Page 18-1**).
6. Turn the key switch to the ON position and check for fuel leaks. Repeat as necessary to build fuel pressure. Any leaks found must be fixed.

⚠ DANGER

- Repair all fuel leaks before returning the vehicle to service.

7. If no leaks are found, place the neutral lockout switch in the OPERATE position (**Figure 18-1, Page 18-1**).

FUEL PUMP MODULE

See General Warnings on page 1-2.

GENERAL INFORMATION

NOTE: The fuel pump and fuel level sending unit themselves are not replaceable. If necessary, the fuel pump module must be replaced as an assembly.

The fuel pump module can be disassembled to replace the fuel filter.

The EFI gasoline vehicle is equipped with an electric fuel pump. The fuel pump is protected by a filter and pickup screen.

FUEL PUMP MODULE REMOVAL

1. Turn the key switch to the OFF position and remove the key, place the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Disconnect battery.
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
3. Clean the top of the fuel tank and fuel pump module (1) (**Figure 29-14, Page 29-20**).
4. With a marker pen, make a mark across the top of the module (1) and onto the tank to note orientation before removal.
5. Disconnect wire harness plug (2).
6. Disconnect the fuel line (3) and drain into an appropriate container. **See Fuel Line Removal on page 22-13. See following WARNING.**

⚠ WARNING

- Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. **See Relieving Fuel Pressure on page 22-11.**
 - Carefully drain any fuel remaining in the hose or pump module into an approved container. Add drained fuel back into fuel tank or dispose of properly.
7. Loosen fuel tank retaining strap (4) to allow tank to move and provide access to all of the fuel pump module hardware (5).
 8. Remove hardware (5) securing hold down ring (6) and ground wire (7) to fuel tank.
 9. Lift fuel pump module (1) out of fuel tank and drain into an appropriate container. Discard fuel module o-ring (8). **See preceding WARNING and following NOTE.**

NOTE: If equipped with a fuel level sending unit, carefully maneuver module so as to avoid damaging the float arm mechanism.

FUEL PUMP MODULE INSTALLATION

1. Clean the groove on top of fuel tank.
2. Place new fuel module o-ring (8) into groove on top of fuel tank (**Figure 29-14, Page 29-20**).
3. Lower fuel pump module (1) into fuel tank noting correct orientation marked before removal. **See following NOTE and CAUTION.**

NOTE: If equipped with a fuel level sending unit, carefully maneuver module so as to avoid damaging the float arm mechanism.

⚠ CAUTION

- Ensure o-ring stays seated in place during fuel pump module installation.
4. Install hold down ring (6) and ground wire (7) with hardware (5) and tighten in a crisscross pattern to 66 in·lb (7.5 N·m). **See following WARNING.**

⚠ WARNING

- Always install ground wires during reassembly.
5. Tighten fuel tank retaining strap screw (9) to 26.5 in·lb (3 N·m).

6. Connect fuel line (3) to fuel pump module (1). **See Fuel Line Installation on page 22-15. See following DANGER.**

DANGER

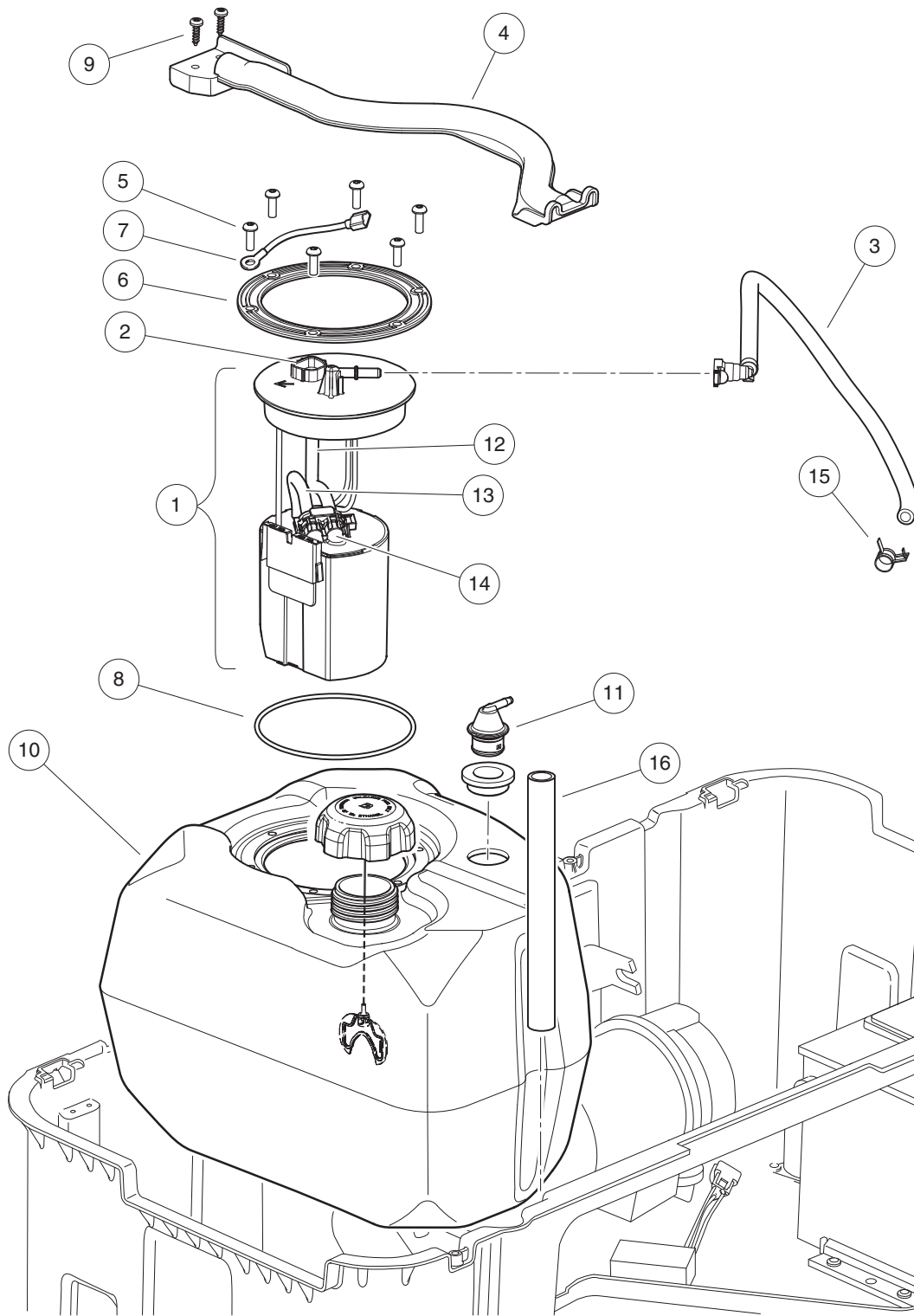
- Ensure line is connected properly to avoid a leak that can cause a fire.
- Make sure fuel line is the correct length and properly routed. Failure to heed this warning could result in damage to fuel line and fire.

7. Connect wire harness plug (2) to fuel pump module (1).
8. Clean spilled and remove any drained gasoline from the area.
9. Connect battery.
See Connect the Battery - Gasoline Vehicles on page 1-4.
10. Place the Forward/Reverse handle in the NEUTRAL position, chock the wheels, and the neutral lockout switch in the MAINTENANCE position (**Figure 18-1, Page 18-1**).
11. Turn key switch to the ON position and check for fuel leaks. Repeat as necessary to build fuel pressure. Any leaks found must be fixed.

DANGER

- Repair all fuel leaks before returning the vehicle to service.

12. If no leaks are found, place the neutral lockout switch in the OPERATE position (**Figure 18-1, Page 18-1**).



3125a

Figure 29-14 Fuel System

FUEL TANK

See General Warnings on page 1-2.

GENERAL INFORMATION

The vehicle is equipped with a high impact, plastic fuel tank.

WARNING

- If the fuel tank is damaged, replace it. Do not attempt to repair it. See the following tank removal and disposal procedure.

CAUTION

- Add only unleaded fuel to the tank. Do not put oil in the fuel tank.

NOTE: This gasoline vehicle complies with the California Air Resources Board (CARB) and EPA evaporative emissions regulations when equipped with SAEJ30R9 1/4 in (6.3 mm) fuel vent hose and 3/16 in (4.78 mm) fuel vent hose. To remain in compliance with California and EPA regulations, replace any fuel vent hose on this vehicle with Club Car fuel vent hoses or equivalent.

FUEL TANK REMOVAL

1. Place the Forward/Reverse handle in the NEUTRAL position, chock the wheels, and the neutral lockout switch in the MAINTENANCE position.
2. Turn key switch to OFF position and remove key.
3. Disconnect battery.
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
4. Clean the top of the fuel tank (10) and fuel pump module (1) (**Figure 29-14, Page 29-20**).
5. Remove gas cap and siphon all fuel from tank into an approved container. **See following DANGER and WARNING.**

DANGER

- Gasoline – Flammable! Explosive! Do not smoke. Keep sparks and flames away from the vehicle and service area. Service only in a well-ventilated area.

WARNING

- Do not attempt to siphon fuel using a hose that does not have a built-in suction device.
 - Do not attempt to siphon fuel using your mouth.
6. Disconnect wire harness plug (2) from fuel pump module (1).
 7. Disconnect vent hose from fuel tank vent (11).
 8. Disconnect the fuel line (3) from the fuel pump module (1) and drain into an appropriate container. **See Fuel Line Removal on page 22-13. See following WARNING.**

⚠ WARNING

- Fuel may be under pressure. Use extreme caution when disconnecting fuel line to prevent the spray of fuel onto hot engine. See Relieving Fuel Pressure on page 22-11.
 - Carefully drain any fuel remaining in the hose or pump module into an approved container. Add drained fuel back into fuel tank or dispose of properly.
9. Disconnect fuel pump module ground wire (7).
 10. Remove screws (9) holding the forward end of the fuel tank retainer (4). Lift up on the forward end of the retainer (4) and unhook the rear end from the fuel bucket.
 11. If equipped, remove retention tube (16) from between fuel tank (10) and fuel bucket.
 12. Lift the fuel tank (10) from vehicle.

FUEL TANK DISPOSAL

1. Remove gas cap and fuel pump module from tank. See Fuel Pump Module Removal on page 22-17. The cap may be discarded or kept as a spare.
2. In a well-ventilated area, flush the fuel tank with water to remove any remaining fuel.
3. In a well-ventilated area, set the tank upside down so that the water can drain out of it. To make sure that the tank dries completely, allow the tank to sit for 24 hours. See following CAUTION.

⚠ CAUTION

- Dispose of wastewater and fuel tank in accordance with local, state, and federal laws and ordinances.

FUEL TANK STORAGE

1. Remove gas cap and fuel pump module from tank. See Fuel Pump Module Removal on page 22-17.
2. In a well-ventilated area, flush the fuel tank with water to remove any remaining fuel.
3. In a well-ventilated area, set the tank upside down so that the water can drain out of it. To make sure that the tank dries completely, allow the tank to sit for 24 hours.
4. Completely drain gas from fuel pump module and allow to module to dry.
5. After module is completely dry, install in fuel tank. See Fuel Pump Module Installation on page 22-19.
6. Store the tank upside down, with the cap installed, in a well-ventilated area.

FUEL TANK INSTALLATION

NOTE: This gasoline vehicle complies with the California Air Resources Board (CARB) and EPA evaporative emissions regulations when equipped with SAEJ30R9 1/4 in (6.3 mm) fuel vent hose and 3/16 in (4.78 mm) fuel vent hose. To remain in compliance with California and EPA regulations, replace any fuel vent hose on this vehicle with Club Car fuel vent hoses or equivalent.

1. Place fuel tank (10) in vehicle.
2. Insert retention tube (16) between fuel tank (10) and fuel bucket.
3. Secure tank with retainer (4).
- 3.1. Insert the tabs on the rear of the retainer (4) into the slots on the back of the fuel bucket (**Figure 29-14, Page 29-20**).
- 3.2. Pivot retainer (4) to place the front edge over mounting holes. Install screws (9) to secure the retainer. Tighten screws to 31 in-lb (3.5 N·m).

4. Connect fuel pump module ground wire (7) to main wire harness. **See following WARNING.**

WARNING

- Always install ground wires during reassembly.

5. Connect fuel line (3) to fuel pump module (1). **See Fuel Line Installation on page 22-15. See following DANGER.**

DANGER

- Ensure line is connected properly to avoid a leak that can cause a fire.
- Make sure fuel line is the correct length and properly routed. Failure to heed this warning could result in damage to fuel line and fire.

6. Connect wire harness plug (2) to fuel pump module (1).
7. Clean spilled and remove any drained gasoline from the area.
8. Connect battery.
See Connect the Battery - Gasoline Vehicles on page 1-4.
9. Add fuel to tank.
10. Place the Forward/Reverse handle in the NEUTRAL position, chock the wheels, and the neutral lockout switch in the MAINTENANCE position (**Figure 18-1, Page 18-1**).
11. Turn key switch to the ON position and check for fuel leaks. Repeat as necessary to build fuel pressure. Any leaks found must be fixed.

DANGER

- Repair all fuel leaks before returning the vehicle to service.

12. If no leaks are found, place the neutral lockout switch in the OPERATE position (**Figure 18-1, Page 18-1**).

FUEL FILTER

See General Warnings on page 1-2.

GENERAL INFORMATION

The fuel filter is located in the fuel tank. It is part of the fuel pump module assembly and should last the life of the vehicle; however, it is replaceable if the need should arise. In addition, the module assembly features a fuel pickup screen to catch larger particles before entering the fuel filter.

FUEL FILTER REMOVAL

1. Turn the key switch to the OFF position and remove the key, place the Forward/Reverse handle in the NEUTRAL position, and chock the wheels.
2. Disconnect battery.
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
3. Remove fuel pump module (1). **See Fuel Pump Module Removal on page 22-17.**
4. Disconnect flex hoses (12 and 13) from filter (14) (**Figure 29-14, Page 29-20**).
 - 4.1. Pull hose retainer clip straight up and out of filter (14). Do not discard clip.
 - 4.2. Pull flex hoses (12 and 13) straight out of filter inlet and outlet.
5. Remove filter (14) from module (1) and dispose of properly.

FUEL FILTER INSTALLATION

CAUTION

- Fuel filter flex hoses are keyed to aid proper installation into fuel pump module.

NOTE: The fuel filter is keyed to the fuel pump module to prevent incorrect assembly.

The inlet and outlet flex hoses are keyed to the fuel filter ports to prevent incorrect assembly.

1. Orient fuel filter (14) and insert into fuel pump module (1) until fully seated (**Figure 29-14, Page 29-20**).
2. Connect flex hoses (12 and 13) to the fuel filter (14).
 - 2.1. Orient flex hoses (12 and 13) with matching port in filter (14) and push each hose end straight into filter until fully seated.
 - 2.2. Push hose retainer clip straight into filter (14) until fully seated.
3. Install fuel pump module (1). **See Fuel Pump Module Installation on page 22-19.**
4. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.
5. Place the Forward/Reverse handle in the NEUTRAL position, chock the wheels, and the neutral lockout switch in the MAINTENANCE position (**Figure 18-1, Page 18-1**).
6. Start the engine and check for fuel leaks. **See following DANGER.**

DANGER

- Repair all fuel leaks before operating the vehicle.

7. If no leaks are found, place the neutral lockout switch in the OPERATE position (**Figure 18-1, Page 18-1**).

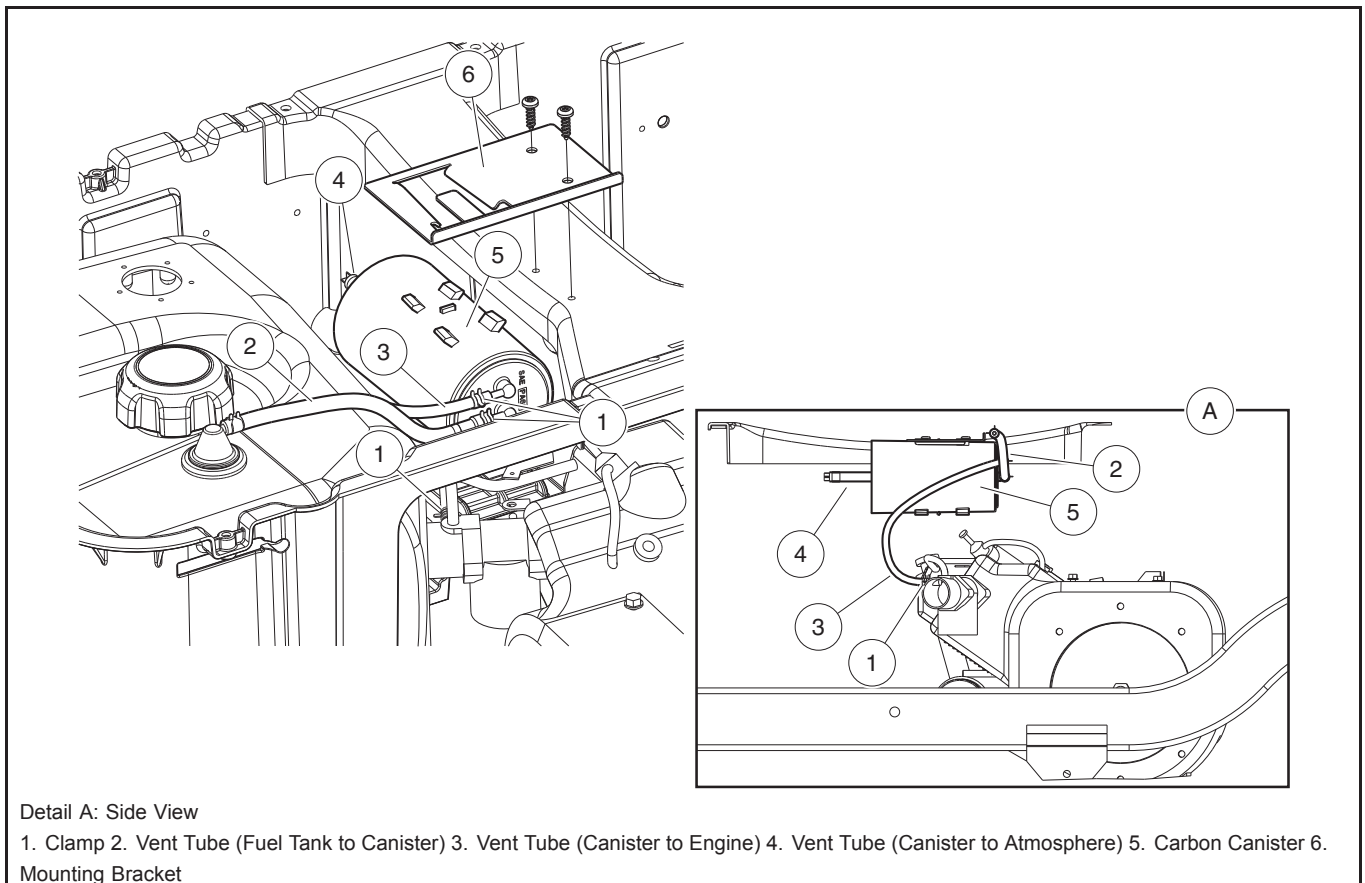
CARBON CANISTER

⚠ WARNING

- If the carbon canister is damaged, only use an OEM (Club Car) replacement that is specifically designed and approved for use on this vehicle. Do not attempt to repair it. See the following canister removal procedure.

CARBON CANISTER REMOVAL

1. Disable the vehicle. **See Disabling the Vehicle on page 1-3.**
2. Raise or remove seat bottom from vehicle.
3. Remove hose clamps (1), securing three hoses (2, 3, and 4) to canister (5), and disconnect hoses (**Figure 29-15, Page 29-25**).
4. Push or pull canister from mounting bracket (6).



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Figure 29-15 Carbon Canister, Hoses and Routing

CARBON CANISTER INSTALLATION

1. Align canister mounting tabs with slots in mounting bracket (6) and push canister (5) into bracket (**Figure 29-15, Page 29-25**). Force it in until fully seated.

2. Attach hoses (2, 3, and 4) to appropriate locations on carbon canister and secure with hose clamps (1).
3. Install and/or lower seat bottom.

⚠ DANGER

- See General Warnings on page 1-2.

⚠ WARNING

- See General Warnings on page 1-2.

MUFFLER**MUFFLER REMOVAL**

1. Disconnect battery and spark plug wire(s). **See Disconnect the Battery - Gasoline Vehicles on page 1-3.**
2. If equipped, remove air deflector from top of engine.
3. Remove the locknut (1) securing the muffler (2) to its mounting bracket (**Figure 30-1, Page 30-2**).
4. Remove the hex nuts (3) and lock washers (4) at the cylinder head and remove muffler (2) from vehicle.

MUFFLER INSTALLATION

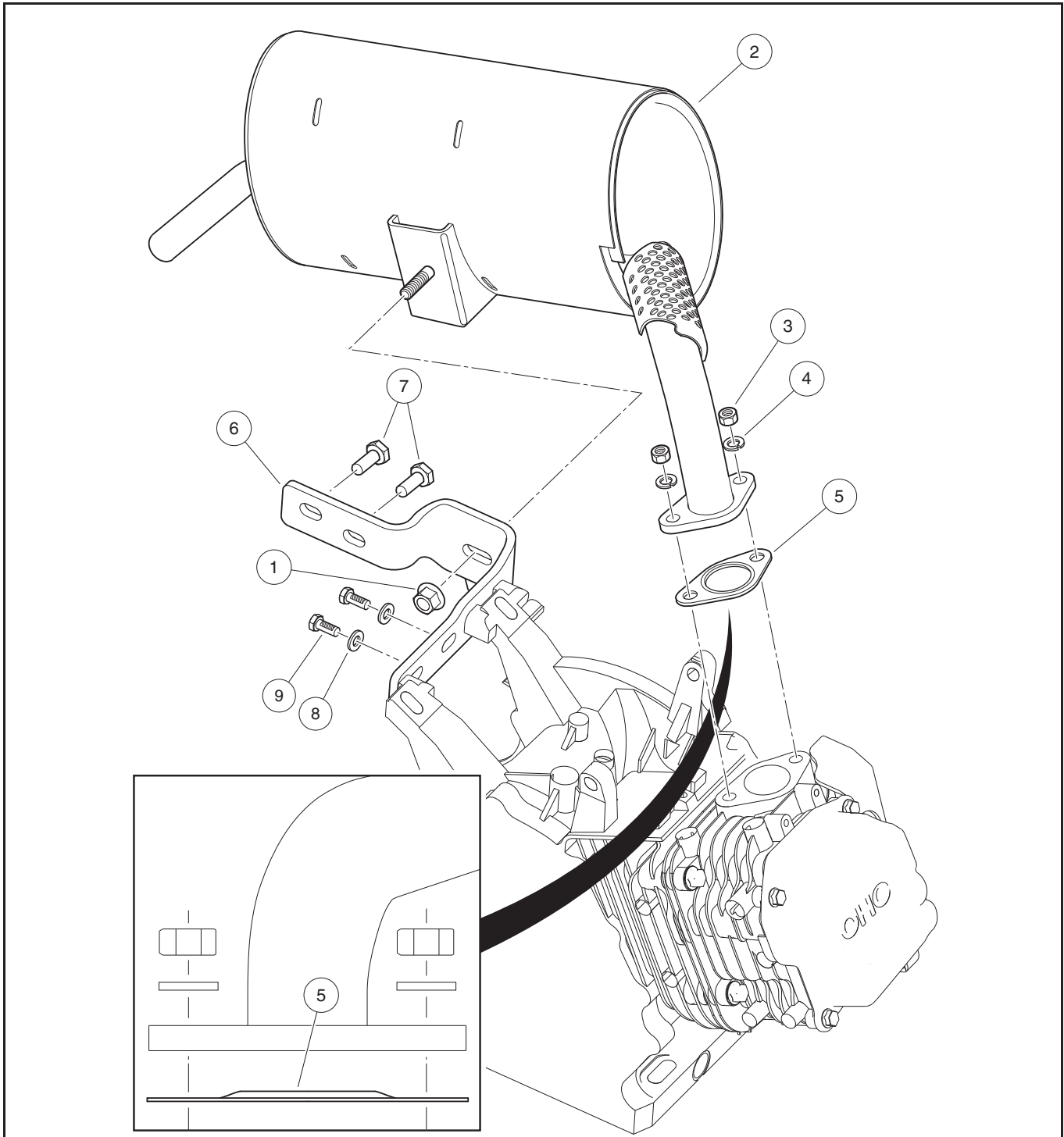
NOTE: Any time the muffler is removed from the vehicle, install a new exhaust gasket (5).

Two different exhaust gaskets have been used; one with a raised port opening, that has since been replaced by the other; a flat, metal-reinforced, graphite gasket. Follow instructions below for proper orientation of the exhaust gasket with raised port opening.

1. If muffler bracket (6) was loosened or removed, tighten bolts (9) to 17 ft·lb (23 N·m) and then bolts (7) to 50 ft·lb (68 N·m) (**Figure 30-1, Page 30-2**).
2. Replace exhaust gasket (5) on the cylinder head exhaust port studs with a new gasket. For exhaust gasket with raised port opening, orient gasket (5) with raised section of gasket up against the flange of the muffler.
3. Place muffler (2) into position and loosely secure it to mounting bracket with locknut (1) and to cylinder head with lock washers (4) and hex nuts (3).
4. Tighten hardware in the following order:
 - 4.1. At the cylinder head, tighten passenger-side hex nut (3) to 15 ft·lb (20 N·m).
 - 4.2. At the cylinder head, tighten driver-side hex nut (3) to 15 ft·lb (20 N·m).
 - 4.3. At the mounting bracket, tighten locknut (1) to 34 ft·lb (46 N·m).
5. If equipped, install air deflector on top of engine.
6. Connect battery and spark plug wire(s). **See Connect the Battery - Gasoline Vehicles on page 1-4.**
7. Place the shifter handle in NEUTRAL, the neutral lockout switch in MAINTENANCE, and chock the wheels.
8. Start the engine and check for exhaust leaks and proper engine operation. **See following DANGER.**

⚠ DANGER

- Do not operate gasoline vehicle in an enclosed area without proper ventilation. The engine produces carbon monoxide, which is an odorless, deadly poison.



3112a

Figure 30-1 Exhaust System

⚠ DANGER

- See General Warnings on page 1-2.

⚠ WARNING

- See General Warnings on page 1-2.

GENERAL INFORMATION

The torque converter consists of a drive clutch, a driven clutch, and a drive belt. The drive clutch, which is mounted to the engine, is in the open position when the engine is at idle. At this point, the belt is riding at a low position (smaller diameter) on the drive clutch. The driven clutch is mounted on the transaxle. It is in the closed position, and the drive belt is riding at a high position (large diameter) on it when the engine is at idle.

At the point of clutch engagement, the speed ratio of the drive clutch to the driven clutch provides excellent starting and low-speed torque.

As engine speed increases, centrifugal force on internal weights close the drive clutch, pushing the belt up to a higher position on the clutch (increasing the diameter of the belt loop). As the diameter of the belt loop increases at the drive clutch, the driven clutch is forced open as the diameter of its belt loop decreases.

On steep grades, or when the vehicle is heavily loaded, higher torques are achieved through the use of a torque-sensing ramp device on the driven clutch. This device overcomes the force of the centrifugal weights to close the driven clutch and open the drive clutch, thus increasing axle torque with little or no change in engine RPM.

The engine and torque converter rotate counter-clockwise as viewed from the clutch side of the engine.

To provide optimum performance for the engine and powertrain, the vehicle uses a pair of tuned clutches.

To properly assemble and disassemble the torque converter, the following tools should be used:

- Clutch Tools (**Figure 31-1, Page 31-2**).
- Scribe or small pick (not included with clutch tools).

TROUBLESHOOTING

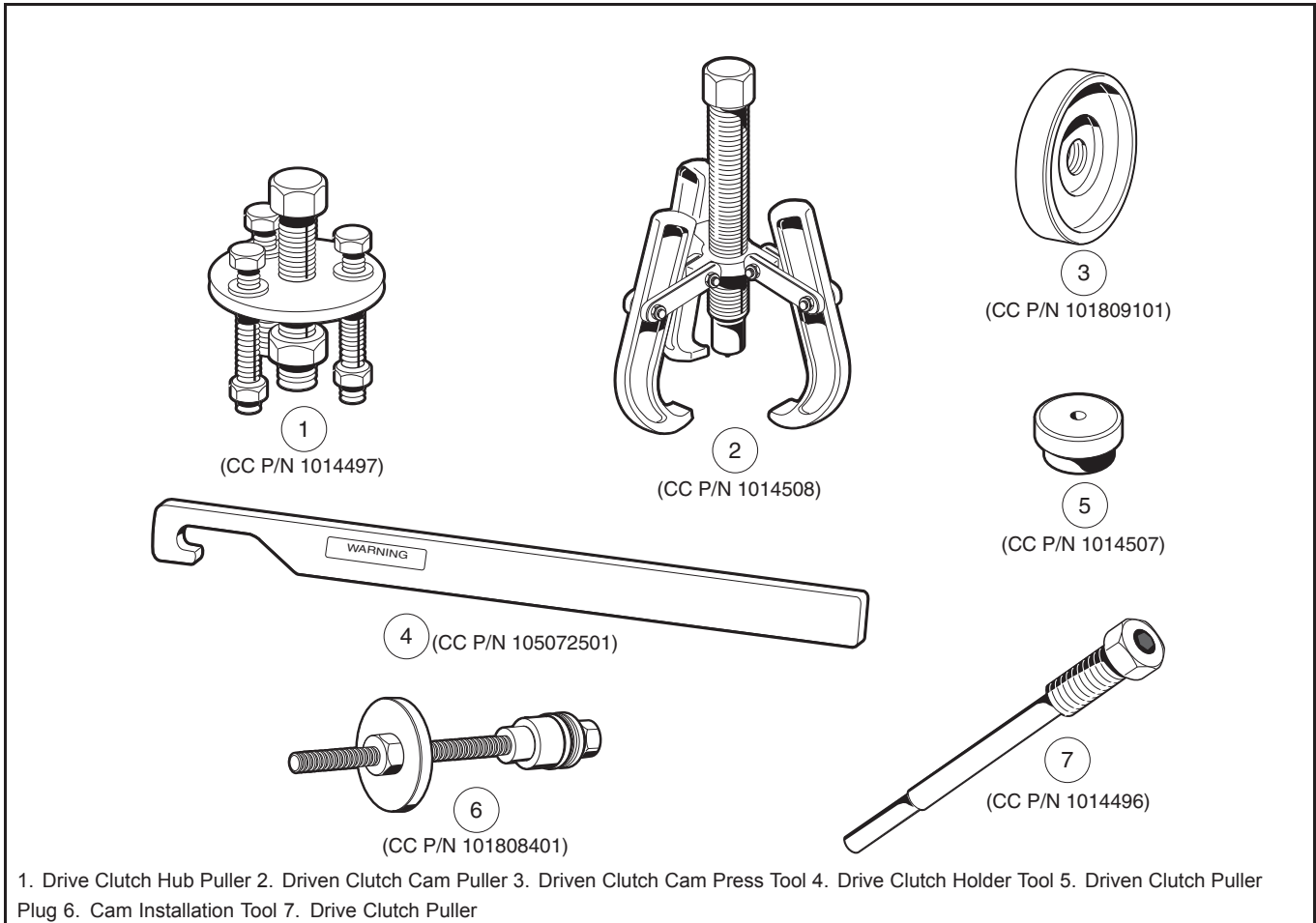
See General Warnings on page 1-2.

Maintaining proper adjustment of the engine and governor, as well as the torque converter, is essential to the troubleshooting process. If these adjustments are within specifications and, when climbing a steep hill, the engine begins to lose RPM before the drive belt reaches the top of the driven clutch, there is a torque converter problem.

If the torque converter is not operating properly, perform the following steps:

1. Check the governor and throttle settings. **See Engine Control Linkages on page 22-2.**
2. Inspect the driven clutch for dirt and dust buildup on its component parts. Clean the driven clutch with water to remove any dust or dirt, then drive the vehicle and check for proper operation.

3. If cleaning the driven clutch does not solve the problem, disassemble and thoroughly clean all parts of the drive clutch. Be sure to clean the plastic drive buttons (7) (Figure 24-2, Page 24-4).



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Figure 31-1 Clutch Tools

DRIVE BELT

See General Warnings on page 1-2.

The drive belt should be inspected semiannually for wear and (or) glazing. If it is excessively worn, frayed, or glazed, replace the belt.

As the drive belt wears, the engine RPM will increase to compensate for the change in torque converter ratio. This will keep the vehicle's maximum ground speed correct. **Section 2 — Vehicle Specifications**

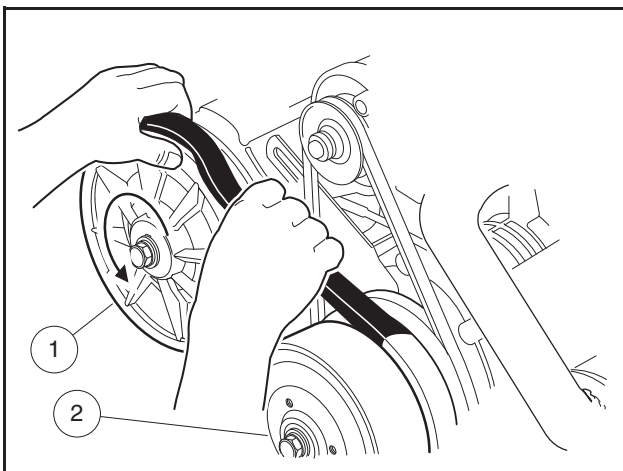
DRIVE BELT REMOVAL

1. Disconnect battery and spark plug wire(s).
See Disconnect the Battery - Gasoline Vehicles on page 1-3.
2. Grasp the belt midway between the drive (2) and driven (1) clutches. Lift upward on the belt to force the sheaves of the driven clutch (1) apart, then roll the belt off the driven clutch by rotating the clutch counterclockwise (**Figure 24-1, Page 24-3**). **See following CAUTION.**

⚠ CAUTION

- Make sure fingers are not underneath the belt when rolling the belt off the driven clutch.

3. Remove the belt from the drive clutch (2).



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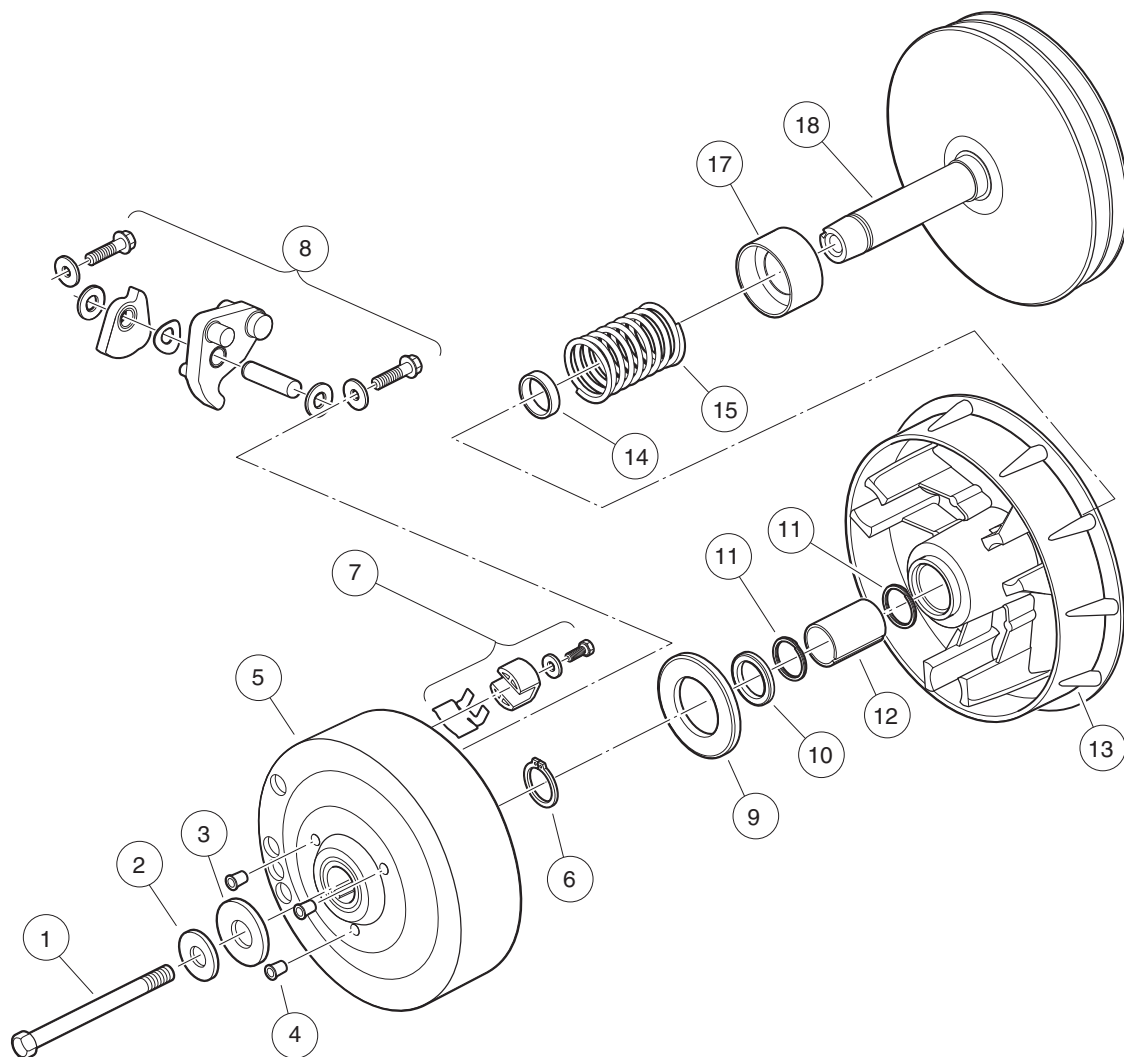
Figure 31-2 Drive Belt Removal

DRIVE BELT INSTALLATION

1. Position the new belt on the drive clutch (2), then start the belt over the top of the driven clutch (1).
2. With the belt started onto the driven clutch (1), rotate the driven clutch counterclockwise and roll the belt over the outer, moveable sheave.
3. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.

DRIVE CLUTCH

See General Warnings on page 1-2.



1. Screw, 3/8-24 x 5.75, Patch

2. Washer, 3/8, Type A, Flat

3. Washer, Hard, M10

4. Cap Plug

5. Drive Hub Assy, Drive Clutch

6. Ring, 0.810 in. (20.5 mm) Internal Retaining

7. Drive Clutch Button

8. Drive Clutch Weight

9. Thrust Washer

10. Retainer

11. Ring, Spiral Backup

12. Bushing, Split, Drive Clutch

13. Sheave, Moveable, Drive

14. Spacer, Fixed Face Shaft

15. Spring, Drive Clutch

16. No Item to Show

17. Spacer, Idler, Drive

18. Sheave, Fixed, Drive

2960

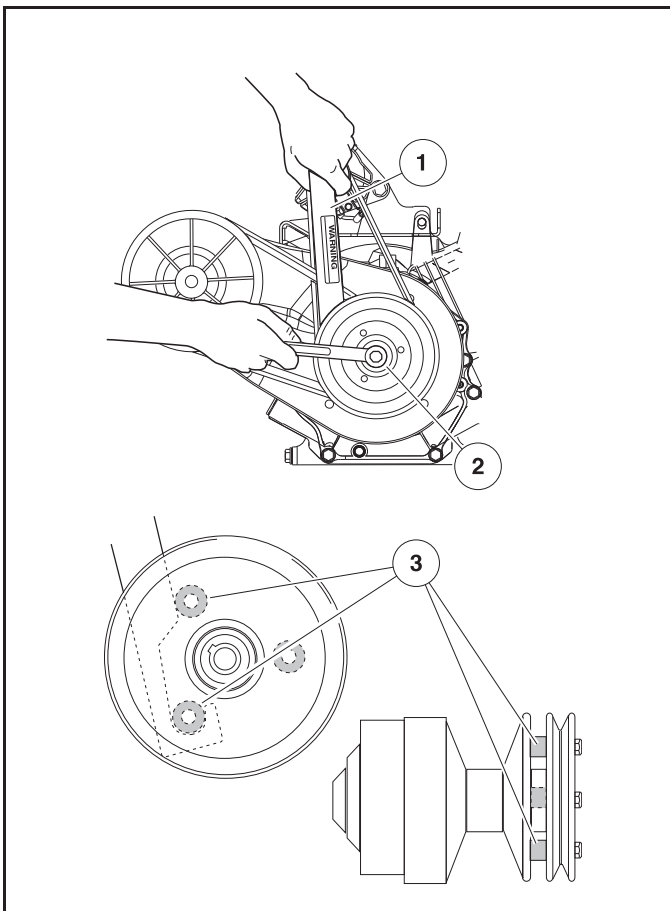
Figure 31-3 Drive Clutch

⚠ CAUTION

- Be very careful when handling the clutches. A clutch that has been dropped will not be properly balanced. If either clutch is dropped, assume that it is damaged and replace it.

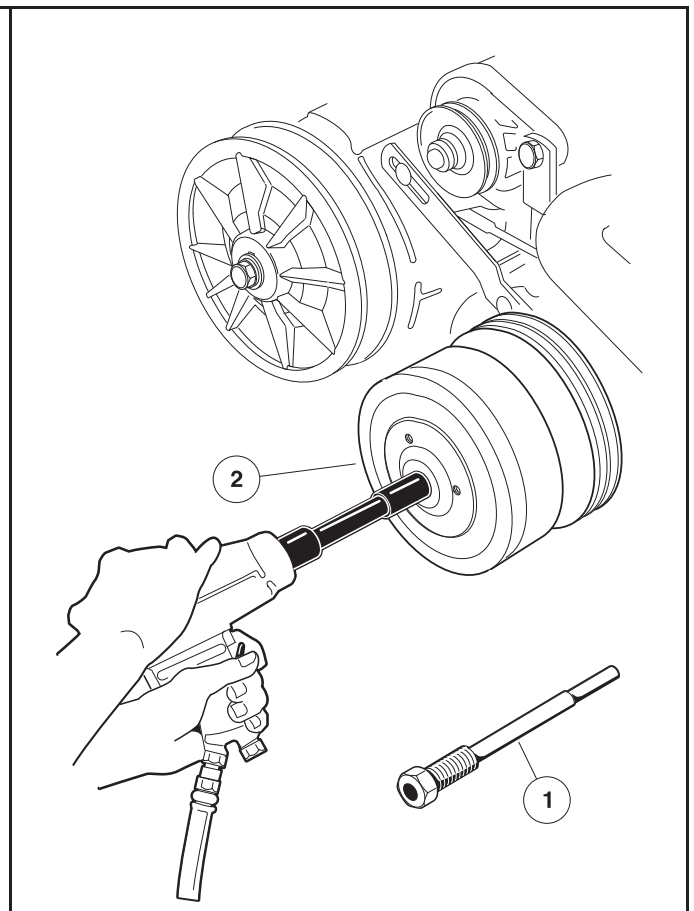
DRIVE CLUTCH REMOVAL

1. Remove the drive belt as instructed. **See Drive Belt Removal on page 24-3.**
2. Loosen starter/generator mounting and adjusting hardware and remove starter belt. **See WARNING “Moving parts! Do not...” in General Warnings on page 1-2.**



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Figure 31-4 Loosen Retaining Bolt



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Figure 31-5 Drive Clutch Removal

3. Place chocks at the front wheels and lift the rear of the vehicle with a chain hoist or floor jack. Place jack stands under the chassis to support the vehicle. The weight of the powertrain will allow the centerline of the drive clutch to drop below the frame I-beam for access to the bolt securing the drive clutch. **See following WARNING.**

⚠ WARNING

- Lift only one end of the vehicle at a time. Use a suitable lifting device (chain hoist or hydraulic floor jack) with 1000 lb. (454 kg) minimum lifting capacity. Do not use lifting device to hold vehicle in raised

WARNING CONTINUED ON NEXT PAGE

⚠ WARNING

position. Use approved jack stands of proper weight capacity to support the vehicle and chock the wheels that remain on the floor. When not performing a test or service procedure that requires movement of the wheels, lock the brakes.

4. Remove the drive clutch retaining bolt (1) and mounting washers (2 and 3) (Figure 24-2, Page 24-4). See also Figure 24-3, Page 24-5. See following NOTE.

NOTE: On Subaru EX-40 engines, the drive clutch mounting bolt has right-hand threads.

- 4.1. Use the drive clutch holder tool (1) while tightening or loosening the drive clutch retaining bolt (2) (Figure 24-3, Page 24-5).
- 4.2. Hook drive clutch holder tool (1) on boss (3) of pulley located behind drive clutch and push against the adjacent boss with holder.
5. Lubricate the threaded portion of the clutch puller tool (1) with a light oil and thread the clutch puller tool into the female thread of the drive clutch (Figure 24-4, Page 24-5).
6. Support the drive clutch with your hand and use a 1/2-in. drive air wrench to tighten the clutch puller tool. The tool will bottom out in the crankshaft and force the drive clutch (2) free of the crankshaft.
7. Remove clutch puller tool from drive clutch.

⚠ CAUTION

- Do not hit or tap the clutch with a hammer. Do not pry the clutch. These actions will damage the clutch.

DRIVE CLUTCH CLEANING AND INSPECTION

1. Use a dry, lint-free cloth to clean clutch parts.

⚠ CAUTION

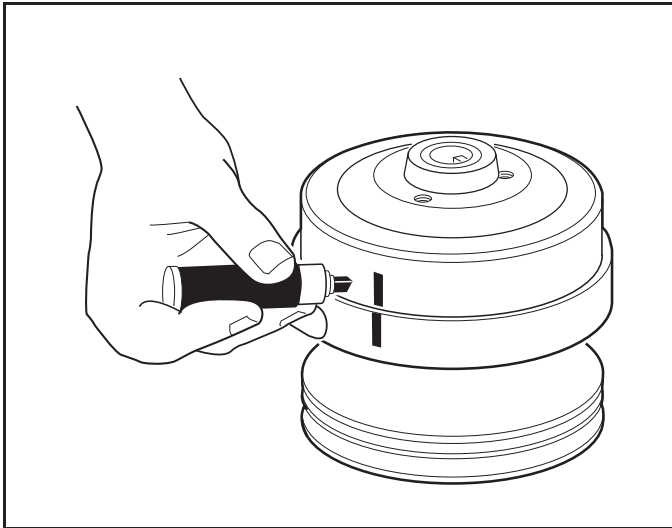
- Do not lubricate the drive clutch. Lubricants attract dirt and dust, which interfere with proper clutch operation.
 - Use only a dry cloth to lightly wipe the shaft of the fixed sheave (18) (Figure 24-2, Page 24-4). Do not use a brush or steel wool. These will damage the surface of the shaft.
 - Do not use solvents. Solvents will damage the lubricating characteristics of the bushings.
2. Inspect the belt contact surfaces of the clutch sheaves for wear. If any area of a sheave contact surface has wear of 0.060 in. (1.52 mm) or more, the clutch should be replaced.

DRIVE CLUTCH DISASSEMBLY

⚠ CAUTION

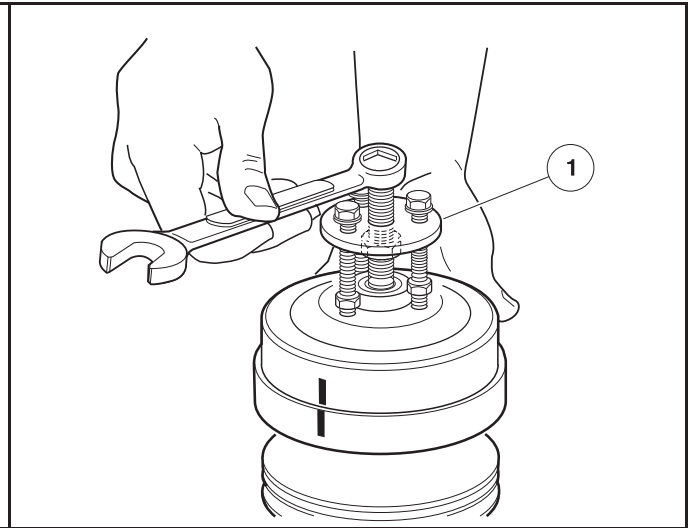
- The drive clutch is balanced as an assembly. Before disassembly, make match marks on the drive clutch hub and on the moveable sheave so they can be reassembled in the same positions (Figure 24-5, Page 24-7).
1. Make match marks on the drive clutch hub and on the moveable face (Figure 24-5, Page 24-7).
 2. Remove the drive clutch hub (5) (Figure 24-2, Page 24-4):

- 2.1. Remove the three plugs (4) from the clutch puller attachment holes.
- 2.2. Thread the center bolt of the Drive Clutch Hub Puller (1) into clutch until the stop nut touches the clutch, then back the bolt out one-half turn (**Figure 24-6, Page 24-7**).
- 2.3. Thread the three small bolts of the puller into corresponding holes in the clutch. Tighten bolts evenly, making sure the face of the puller plate is parallel to the face of the clutch (**Figure 24-6, Page 24-7**).
- 2.4. Unscrew the puller center bolt out of the clutch to pull drive clutch hub off.



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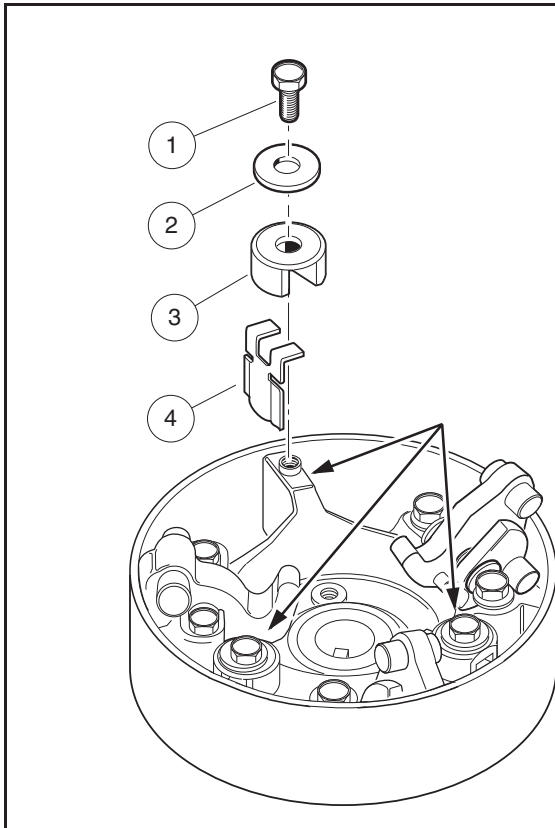
Figure 31-6 Mark Drive Clutch Hub



599

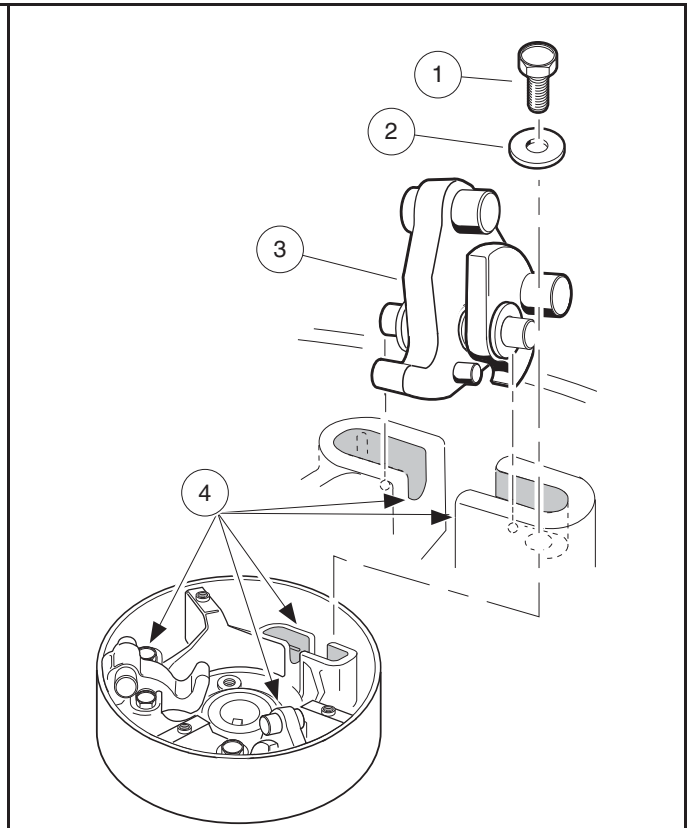
Figure 31-7 Remove Drive Clutch Hub

3. Remove the thrust washer (9) from the moveable sheave (13) (**Figure 24-2, Page 24-4**).
4. Remove the drive buttons (3) by removing the screws (1), flat washers (2), and drive button take-up springs (4) as shown (**Figure 24-7, Page 24-8**).



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Figure 31-8 Drive Button Mounting



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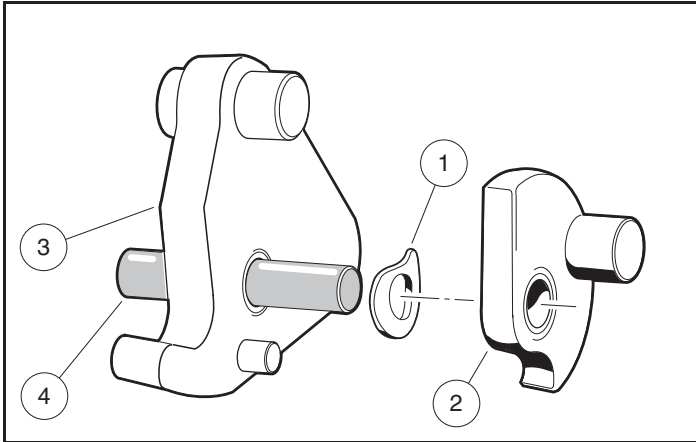
Figure 31-9 Weight Position

5. Remove the clutch weights:

- 5.1. Remove the screws (1) and flat washers (2) attaching the weights (3) as shown (Figure 24-8, Page 24-8).
- 5.2. Pull the weight assemblies (3), with pins, from slots (4) in the clutch. **See following NOTE.**

NOTE: Before removing, note the orientation of the wave washer (1) and secondary weight (2) on the primary weight (3) (Figure 24-9, Page 24-9).

- 5.3. Remove the plastic washers, weights (2 and 3) and wave washer (1) from the pin (4). Retain all parts.



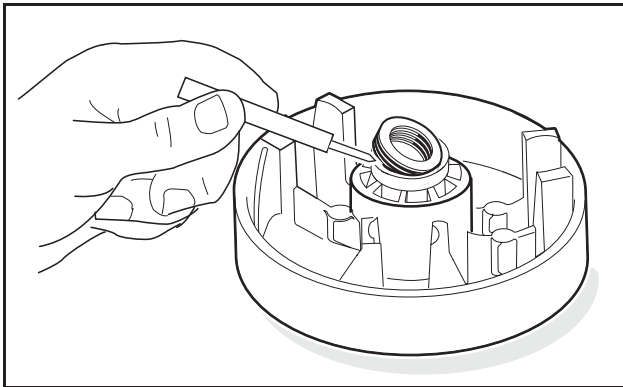
602

Figure 31-10 Primary and Secondary Weights, Wave Washer and Pin

6. Remove the retaining ring (6) from the shaft of the fixed sheave (18) and slide the moveable sheave (13) off the shaft (**Figure 24-2, Page 24-4**). See following **NOTE**.

NOTE: If the moveable sheave is removed from the hub of the fixed sheave, the spiral back-up rings (11) must be replaced with new rings (**Figure 24-2, Page 24-4**).

7. Remove the spacer (14) and spring (15) (**Figure 24-2, Page 24-4**).
8. Use a scribe or small pick to remove the spiral backup rings (11) from each end of the bore in the fixed sheave (**Figure 24-2, Page 24-4**). See also **Figure 24-10, Page 24-9**. Discard the rings.



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Figure 31-11 Spiral Back-up Rings

INSPECTION OF DRIVE CLUTCH PARTS

1. Inspect the idler spacer (17) for smoothness (**Figure 24-2, Page 24-4**).
2. Inspect the bore of the moveable sheave (13) for scarring or wear. The moveable sheave must be replaced if the bore is worn to a diameter of 0.883 in. (22.4 mm) or larger (**Figure 24-2, Page 24-4**).
3. Inspect the steel shaft on the fixed sheave (18). There should be no measurable wear anywhere on the shaft. Replace the shaft if it is worn, scratched, or damaged.
4. Inspect the thrust washer (9) for wear. If it is worn more than 0.030 in. (0.76 mm), turn it over or replace it with a new one.

5. Inspect the primary weights (8) and the hub casting for wear. If the primary weights show signs they are touching the casting, the tips of the weights have worn beyond specification and they must be replaced.
6. Inspect the pins on the primary weights (8). There should be no measurable wear. Replace them if they are worn, scratched, or damaged.
7. Inspect the drive belt pulley sheaves for excessive wear or damage. If the sheaves are excessively worn or damaged, replace the entire fixed sheave.

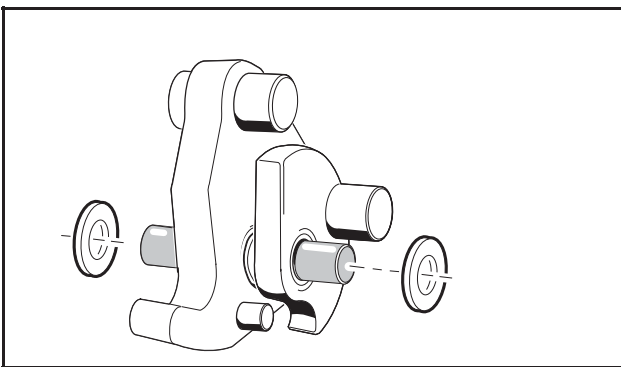
DRIVE CLUTCH ASSEMBLY

1. Install the spring (15) into the cup of the idler spacer (17).
2. Install the spacer (14) onto the shaft of the fixed sheave.
3. Install a new spiral backup ring (11) in each end of the bore of the moveable sheave (13).
4. Install the moveable sheave (13) onto the shaft of the fixed sheave (18).

⚠ CAUTION

- To avoid damaging the spiral back-up rings, be very careful when installing the moveable sheave.

- 4.1. Rotate the moveable sheave clockwise while installing it onto the shaft.
- 4.2. Install the retaining ring (6) (**Figure 24-2, Page 24-4**).
5. Install the primary weights (3) on the mounting pins (4) (**Figure 24-9, Page 24-9**).
6. Install a wave washer (1) on each mounting pin (4). Make sure that the concave side of the washer faces the side of the primary weight (3) with the small guide pin protruding from it (**Figure 24-9, Page 24-9**).
7. Install the secondary weights (2) onto the mounting pins (4) with the weight pins on the secondary weights pointing away from the primary weights (3). The wave washers should be between the primary and secondary weights (**Figure 24-9, Page 24-9**).
8. Install white plastic flat washers on each end of the mounting pin and push them against the outside surfaces of the weights. Center the weights and washers on the mounting pin (**Figure 24-11, Page 24-10**).
9. Install the weight assemblies into the slots (4) in the hub casting (**Figure 24-8, Page 24-8**). Make sure the mounting pin protrudes an equal amount on each side of the weights when the assemblies are in position (**Figure 24-11, Page 24-10**).



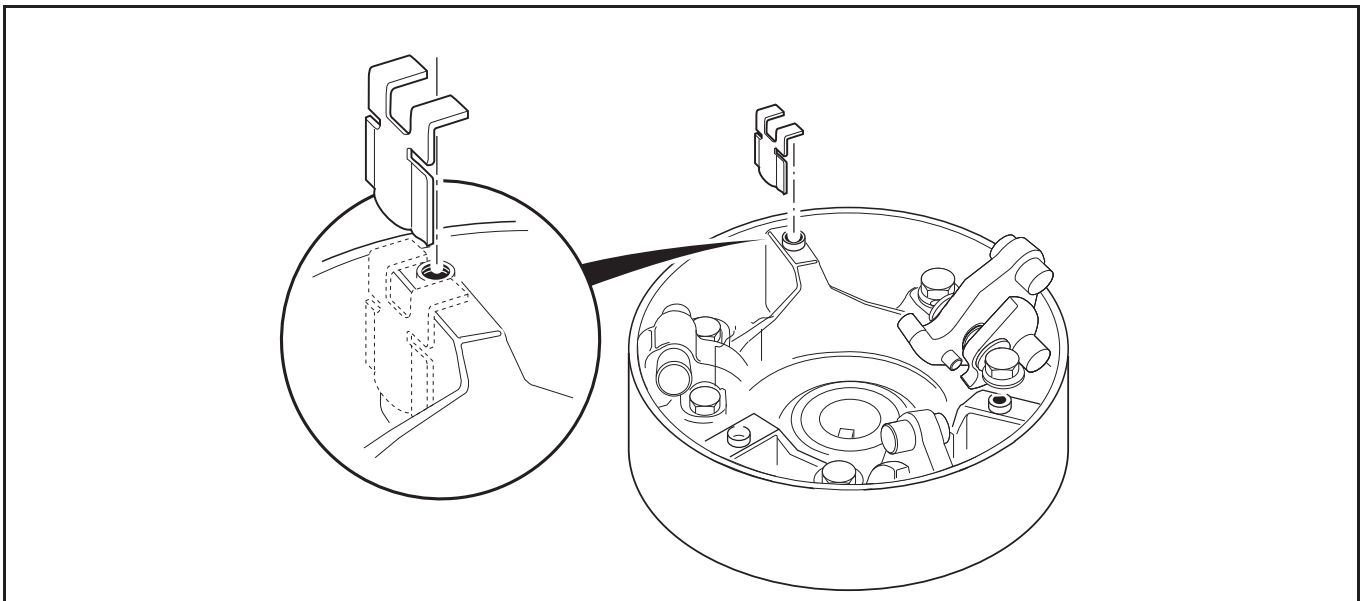
606

Figure 31-12 Install White Washers

10. Install the 1/4-20 bolts (1) and washers (2) and tighten them to 10 ft·lb (13 N·m) (**Figure 24-8, Page 24-8**).
See following NOTE.

NOTE: Make sure there is at least a (minimum) gap of 0.020 in. (0.51 mm) between each end of the mounting pin and the mounting bolt.

11. Install three drive button take-up springs.
- 11.1. Install each spring on right-hand side of the three button mounting posts (when looking into the interior of the clutch drive hub, and with the rib at a twelve o'clock position) as shown (**Figure 24-12, Page 24-11**).
12. Compress each take-up spring and install the drive button over the rib and take-up spring (**Figure 24-7, Page 24-8**).
13. Install a drive button retaining bolt (1) with flat washer (2) through each button (3) and into the rib. Tighten the bolts to 34 in·lb (3.8 N·m) (**Figure 24-7, Page 24-8**).
14. Install the thrust washer (9) onto the moveable sheave (13) (**Figure 24-2, Page 24-4**).
15. Install the hub assembly (5) on the moveable sheave (13) and align the match marks made before disassembling the clutch. Press the hub assembly on by hand.
16. Replace the three plastic plugs (4) into the holes (**Figure 24-2, Page 24-4**).



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Figure 31-13 Correct Orientation of Drive Button Take-up Springs

DRIVE CLUTCH INSTALLATION

1. Place the drive clutch assembly on the crankshaft taper. Position the mounting washers (2 and 3) on the bolt (1) and start the bolt into the crankshaft (**Figure 24-2, Page 24-4**). **See following NOTE.**

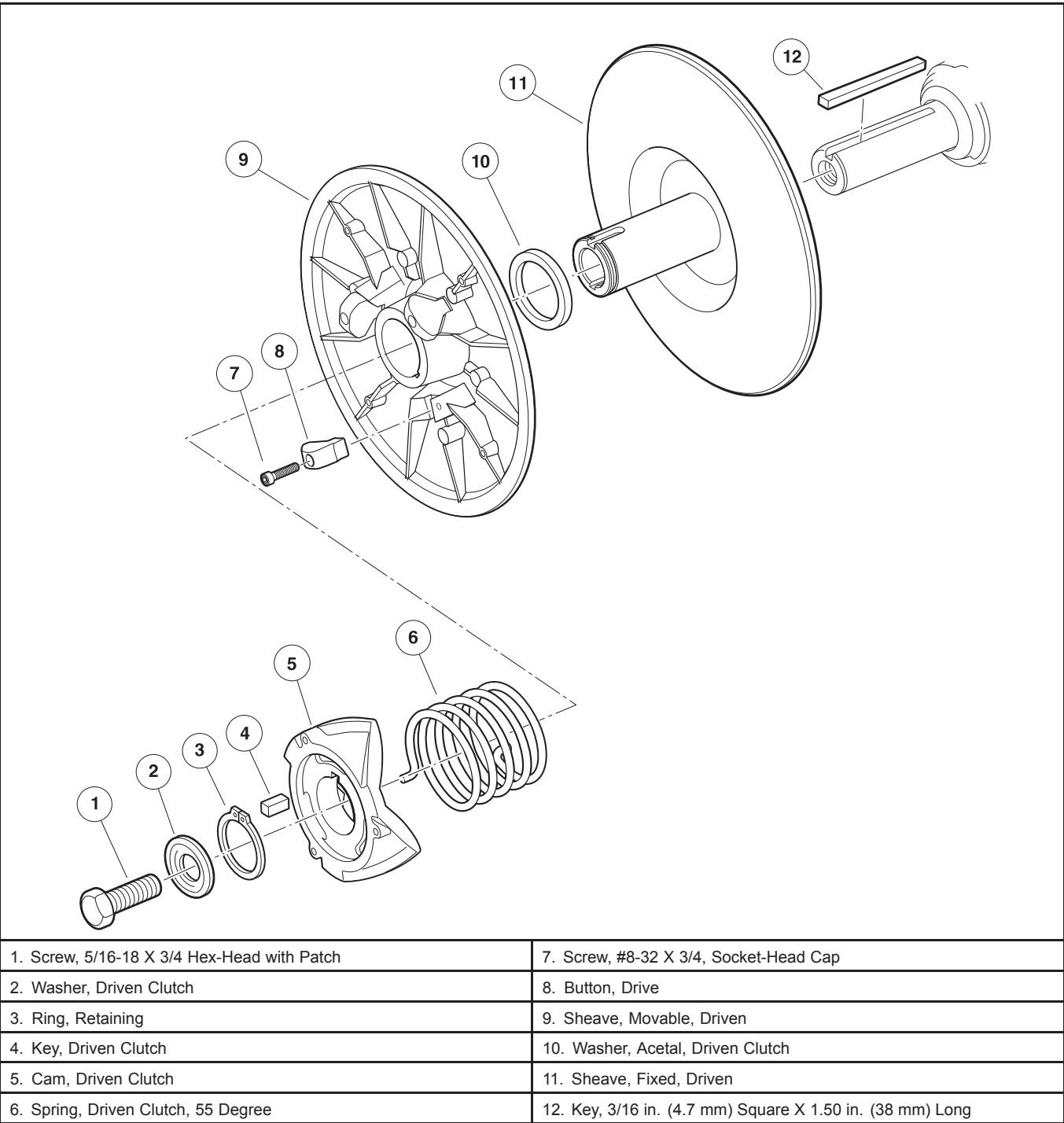
NOTE: The drive clutch retaining bolt has right-hand threads. The manufacturer recommends replacing the drive clutch retaining bolt when installing the drive clutch. If a new bolt is not available, clean the threads of the original bolt and apply Loctite® 242 to the threaded end prior to installation.

2. Tighten the drive clutch retaining bolt (1) to 35 ft·lb (47.5 N·m) (**Figure 24-2, Page 24-4**).
3. Install the starter/generator belt and adjust belt tension as instructed. **See Belt Tension Adjustment for EFI Engines, Section 27, Page 27-13.**
4. Install the drive belt as instructed. **See Drive Belt Installation on page 24-3.**
5. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.

6. Drive the vehicle and check for proper operation.

DRIVEN CLUTCH

See General Warnings on page 1-2.



2961

Figure 31-14 Driven Clutch

DRIVEN CLUTCH REMOVAL

1. Remove the drive belt as instructed. **See Drive Belt Removal on page 24-3.**
2. Remove the bolt (1) and mounting washer (2) from the transaxle input shaft (**Figure 24-13, Page 24-12**). Discard the bolt.

NOTE: The bolt (1) must be replaced with a new bolt containing a locking patch that will prevent the bolt from loosening.

3. Grasp the driven clutch assembly and slide it off the shaft.
4. Leave the key (12) in the keyway (**Figure 24-13, Page 24-12**).
5. Inspect the key for damage. Replace as necessary.

DRIVEN CLUTCH DISASSEMBLY

⚠ CAUTION

- The driven clutch is balanced as an assembly. Before disassembly, make match marks on the driven clutch fixed sheave and moveable sheave so they can be reassembled in the same positions.

1. Make match marks on the driven clutch fixed sheave and on the moveable sheave to maintain balance upon reassembly.
2. Set the edge of the clutch body (1) on a clean, flat surface (**Figure 24-14, Page 24-13**).

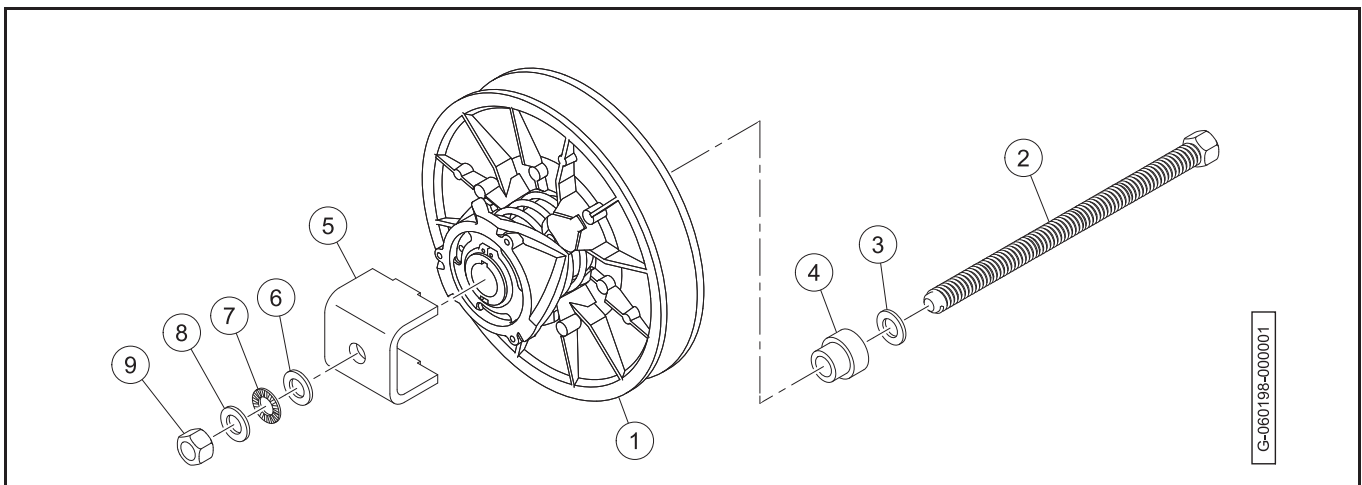


Figure 31-15 Driven Clutch Tool - Disassembly

3. Assemble the threaded bolt (2) through the washer (3) and thrust collar (4).

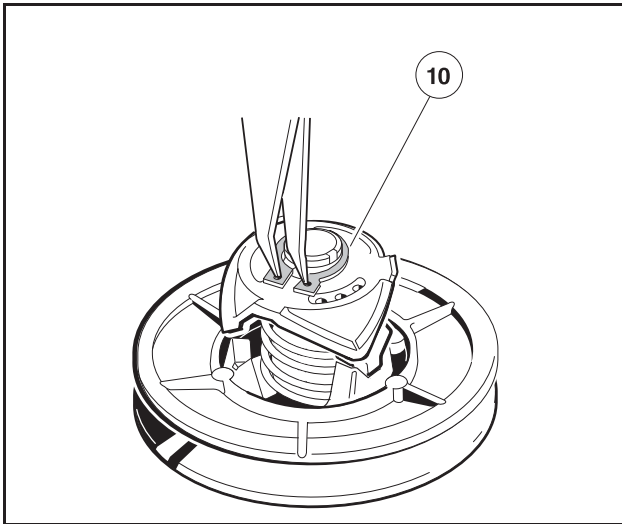
NOTE: It is very important that the bolt, washers, and thrust bearing assembly be assembled in the order described and shown.

4. Slide the threaded bolt assembly through the clutch body until the threaded bolt and thrust collar are against the fixed sheave.
5. Install the cam press plate (5), thrust washer (6), thrust bearing (7), thrust washer (8), and nut (9) onto the threaded bolt.
6. Thread the nut down onto the cam hub, centering the press hub onto the cam hub.
7. Use two wrenches and hold the threaded bolt head while tightening the cam press plate to press the cam onto the keyed shaft. Advance the cam press plate until it is firm against the shaft end.

⚠ WARNING

- Do not place fingers under the cam when removing the cam. The moveable face may spin when the cam buttons release from the cam ramps, resulting in severe personal injury.

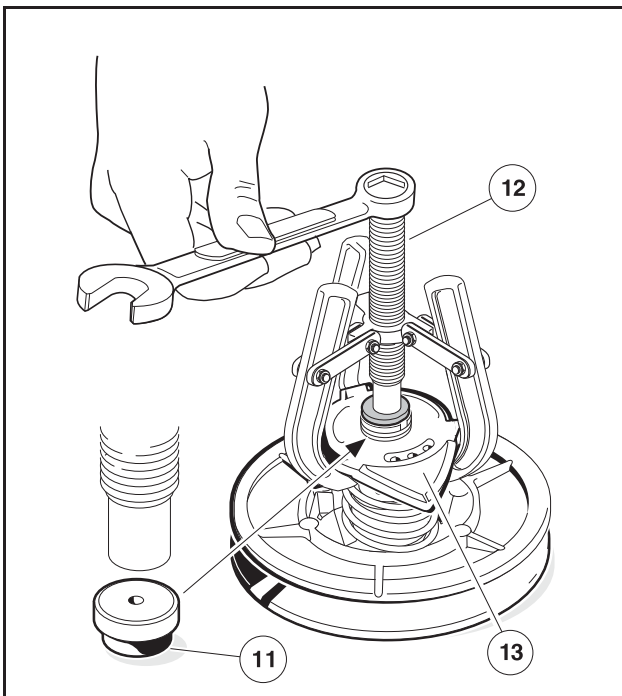
8. Remove the retaining ring (10) (Figure 24-15, Page 24-14).



608B

Figure 31-16 Remove Retaining Ring

9. Insert a puller plug (11) into the shaft bore (Figure 24-16, Page 24-14).

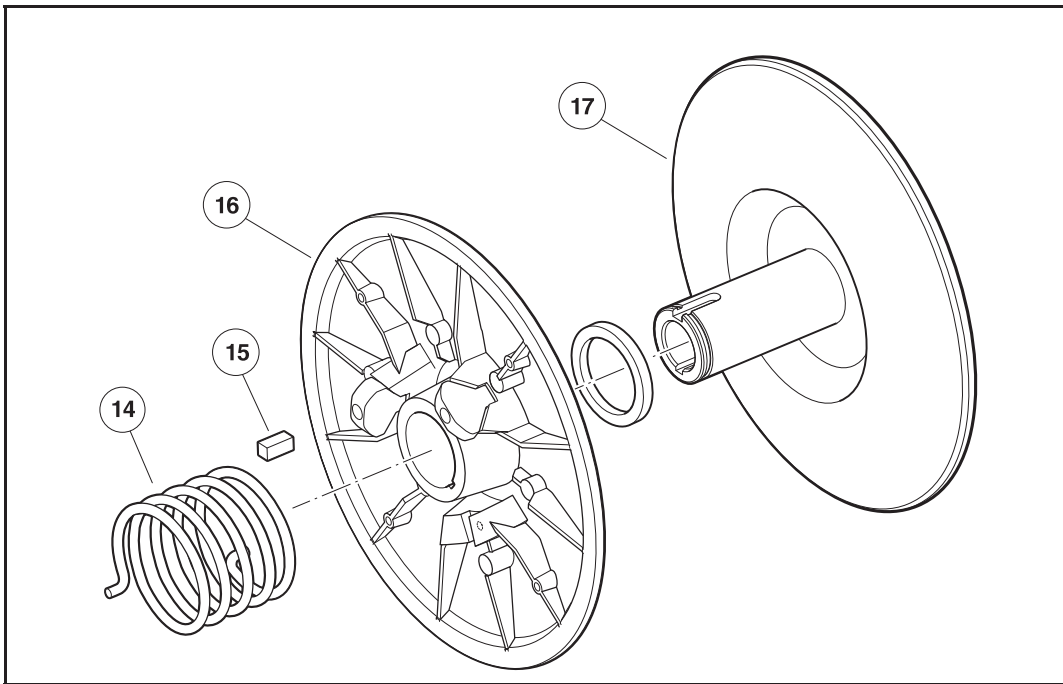


609B

Figure 31-17 Cam Removal

10. Use a driven clutch cam puller (12) to remove the cam (13) from the fixed sheave.

11. Remove the spring (14) (Figure 24-17, Page 24-15).



2961B

Figure 31-18 Driven Clutch Disassembly

12. Inspect the key (15) for damage. Replace as necessary.
 13. Slide the moveable sheave (16) off the fixed sheave (17).

DRIVEN CLUTCH INSPECTION

1. Inspect the cam (5) for excessive wear (Figure 24-13, Page 24-12). Replace it if necessary.
2. Inspect the drive buttons (8) for excessive wear. Replace if necessary. To remove the drive buttons (8), remove the socket-head cap screws (7) and then the buttons.
3. Inspect the smooth surface on the fixed and moveable sheaves. Sheaves must be replaced if surfaces are worn more than 0.060 in. (1.5 mm).
4. Inspect the bronze bearing in the moveable sheave. If the bearing bore diameter is more than 1.384 in. (35.15 mm), the entire moveable sheave must be replaced.
5. Inspect the shaft of the fixed sheave. There should be no noticeable wear. Replace the fixed sheave if it is worn, scratched or damaged.

DRIVEN CLUTCH ASSEMBLY

1. Place the three drive buttons (8) in position. Apply one drop of Loctite® 222 to each of the socket-head cap screws (7) and then install and tighten them to 8 in·lb (0.9 N·m) (Figure 24-13, Page 24-12).
2. Slide the acetal washer (10) and moveable sheave (9) onto the fixed sheave (11).
3. Place the end of the spring (6) into the hole in the moveable sheave (9).
4. Install the key (4) into the keyway of the fixed sheave (11) shaft.
5. Holding the cam (5) in position for assembly on the shaft, install the other end of the spring (6) into the center spring hole of the cam. Rotate the cam until the keyway is aligned with the key (4) on the fixed sheave, and then start the cam onto the shaft approximately 1/4 to 3/8 in. (6.3 to 9.5 mm).

5.1. Press Assembly Process:

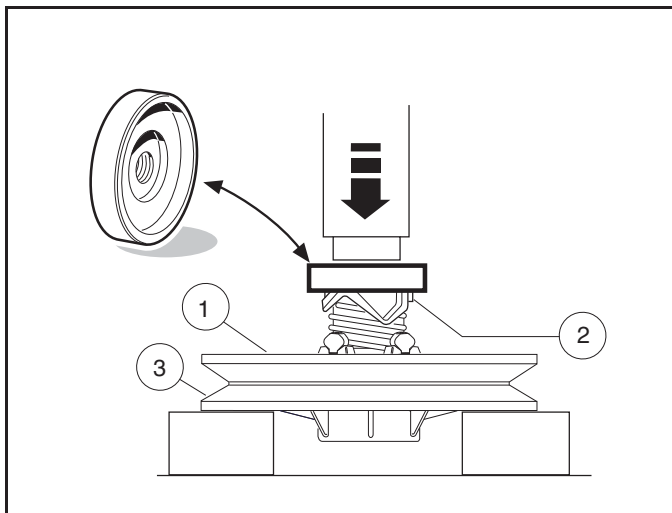
- 5.1.1. Place the clutch assembly in a press and position the cam press tool on the cam (2) as shown (**Figure 31-19, Page 31-17**).
- 5.1.2. Hold the fixed sheave (3) and rotate the moveable sheave (1) one-third turn counterclockwise, then press the cam (2) onto the fixed sheave (**Figure 31-19, Page 31-17**). The match marks made before disassembly should now align.
- 5.1.3. Install the retaining ring (4) . **See following NOTE.**

NOTE: The retaining ring (4) can be reused if the O.D. does not exceed 1.607 in. (40.82 mm); otherwise, it must be replaced with a new ring.

- 5.1.4. While holding onto the cam, tap the end of the fixed sheave lightly with a plastic mallet until the cam seats against the retaining ring (4). **See following CAUTION.**

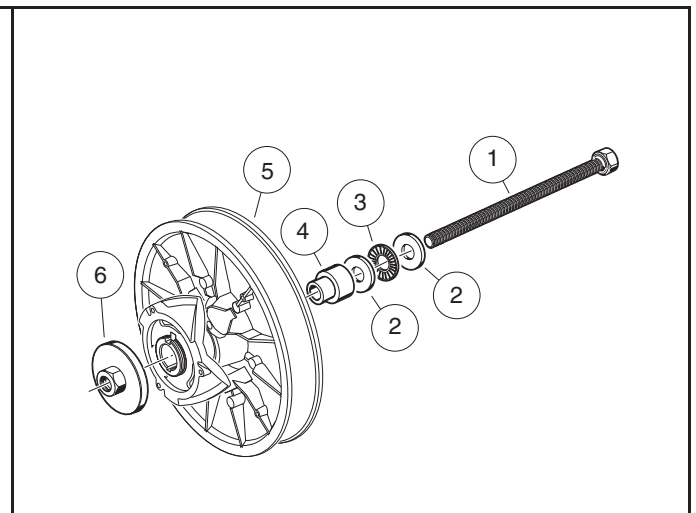
⚠ CAUTION

- Do not use a metal hammer to tap the fixed sheave. A metal hammer will damage the shaft.



611

Figure 31-19 Cam Press Tool



612

Figure 31-20 Cam Installation Tool

5.2. Field Assembly Process:

NOTE: This process is for field assembly requirements where hydraulic and pneumatic press equipment is not available. Use the cam installation tool for this process.

- 5.2.1. With the clutch loosely assembled, set the edge of the clutch body (5) on a clean, flat surface (**Figure 31-20, Page 31-17**).
- 5.2.2. Assemble the threaded bolt (1) through the washer (2), the thrust bearing assembly (3), the second washer (2), and the hub guide (4).

NOTE: It is very important that the bolt, washers, and thrust bearing assembly be assembled in the order described and shown.

- 5.2.3. Slide the bolt (1) through the clutch body (5) until the threaded bolt, washers, bearing, and hub guide are against the fixed sheave (**Figure 31-20, Page 31-17**).

- 5.2.4. Hold the clutch assembly and cam installation tool together and place the fixed sheave down on spaced blocks (**Figure 31-19, Page 31-17**).
- 5.2.5. Place the cam press hub (6) onto the cam installation bolt and thread it down onto the cam hub, centering the press hub onto the cam hub.
- 5.2.6. Hold the fixed sheave of the clutch (5) and rotate the moveable sheave of the clutch one-third turn counterclockwise (**Figure 31-20, Page 31-17**). The match marks made before disassembly should now align.
- 5.2.7. Use two wrenches and hold the bolt head (1) while tightening the cam press hub (6) to press the cam onto the keyed shaft. Advance the press hub (6) until it is firm against the shaft end.
- 5.2.8. Remove the cam press hub (6) and installation tool.
- 5.2.9. Install the retaining ring (4) .

NOTE: The retaining ring (4) can be reused if the O.D. does not exceed 1.607 in. (40.82 mm); otherwise, it must be replaced with a new ring.

DRIVEN CLUTCH INSTALLATION

1. To install the driven clutch, reverse the removal procedure. Make sure that the washer (2) is mounted with the flat portion of the washer against the driven clutch (**Figure 24-13, Page 24-12**). Secure with a new bolt (1).
See following NOTE.

NOTE: The bolt (1) must be replaced with a new bolt containing a locking patch that will prevent the bolt from loosening.

2. Tighten the bolt (1) to 18 ft·lb (24.4 N·m).
3. Connect battery and spark plug wire(s).
See Connect the Battery - Gasoline Vehicles on page 1-4.

GENERAL INFORMATION

Wire Description

EXAMPLE: 18_GRN_RED

- 18 = 18 gauge wire
- GRN_RED = Green wire with red stripe

Wire Colors

NOTE: The following colors will be represented as a black wire in the wiring diagrams:

- Black
- White
- Yellow
- White with Black Stripe

| Abbreviation | Wire Color |
|--------------|------------------------------|
| BLK | Black |
| BLU | Blue |
| LT BLU | Light Blue |
| BRN | Brown |
| GRAY | Gray |
| GRN | Green |
| ORG | Orange |
| PINK | Pink |
| PUR | Purple |
| RED | Red |
| TAN | Tan |
| WHT | White |
| YEL | Yellow |
| BLK_LT_BLUE | Black with Light Blue Stripe |
| BLK_ORG | Black with Orange Stripe |
| BLK_PINK | Black with Pink Stripe |
| BLK_WHT | Black with White Stripe |
| BLK_YEL | Black with Yellow Stripe |
| BLU_WHT | Blue with White Stripe |
| BRN_WHT | Brown with White Stripe |
| GRN_RED | Green with Red Stripe |

TABLE CONTINUED ON NEXT PAGE

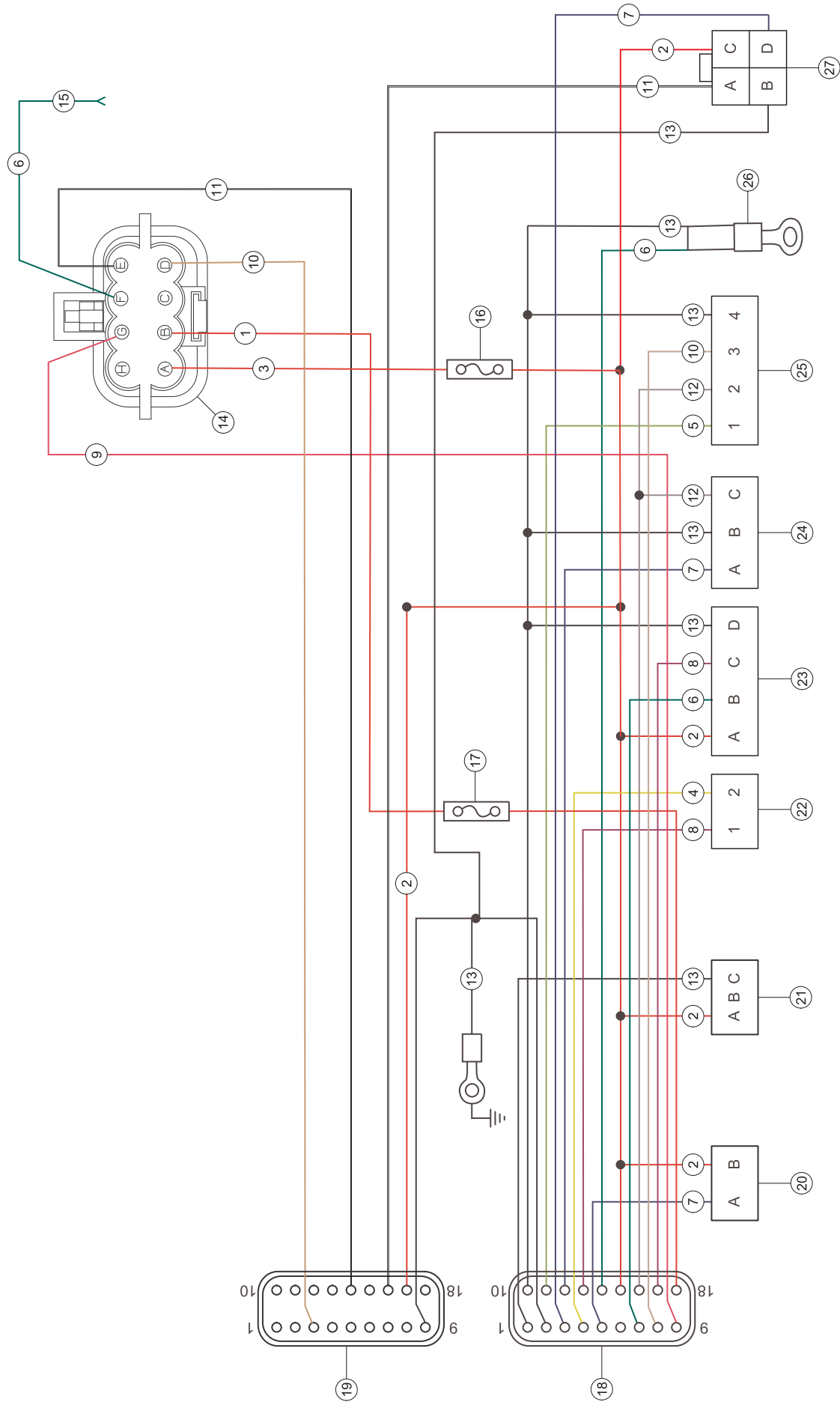
| | |
|---------|--------------------------|
| GRN_WHT | Green with White Stripe |
| ORG_BLK | Orange with Black Stripe |
| ORG_WHT | Orange with White Stripe |
| PUR_WHT | Purple with White Stripe |
| RED_GRN | Red with Green Stripe |
| RED_WHT | Red with White Stripe |
| RED_YEL | Red with Yellow Stripe |
| WHT_BLK | White with Black Stripe |

KOHLER ECH440 ENGINE HARNESS WIRING DIAGRAM TABLE

| Callout | Description |
|---------|-------------------------------|
| 1 | Red |
| 2 | Red/Black |
| 3 | Red/White |
| 4 | Yellow |
| 5 | Light Green |
| 6 | Dark Green |
| 7 | Dark Blue |
| 8 | Purple |
| 9 | Pink |
| 10 | Tan |
| 11 | White |
| 12 | Grey |
| 13 | Black |
| 14 | To Main Harness |
| 15 | Oil Level Switch |
| 16 | 10-amp Fuse (Ignition Switch) |
| 17 | 10-amp Fuse (Battery Power) |
| 18 | Black Connector |
| 19 | Grey Connector |
| 20 | Fuel Injector |
| 21 | Ignition Coil |
| 22 | Crankshaft Position Sensor |
| 23 | Oxygen Sensor |
| 24 | Throttle Position Sensor |
| 25 | TMAP Sensor |
| 26 | Engine Temperature Sensor |
| 27 | Diagnostic Connector |

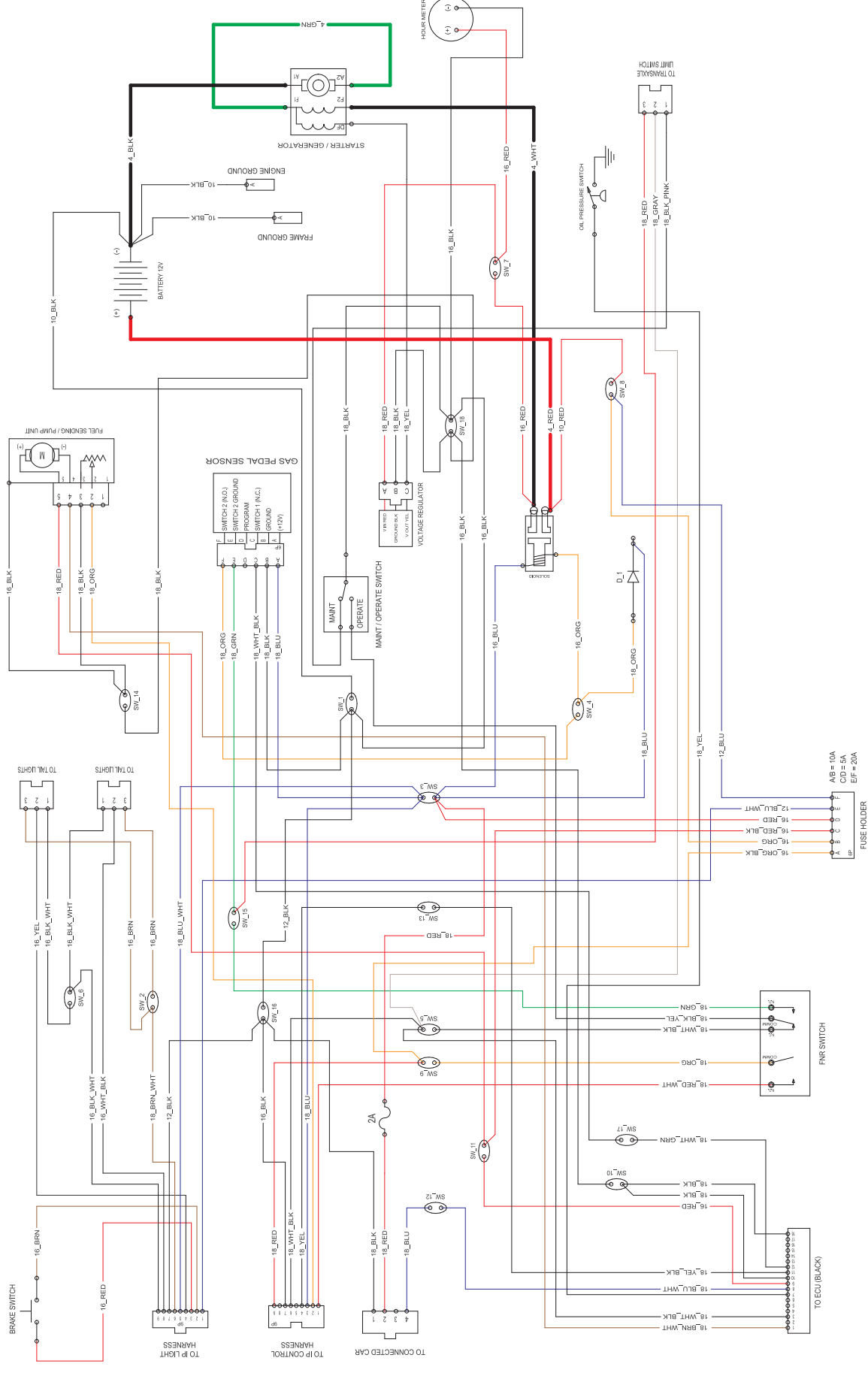
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KOHLER ECH440: ENGINE HARNESS



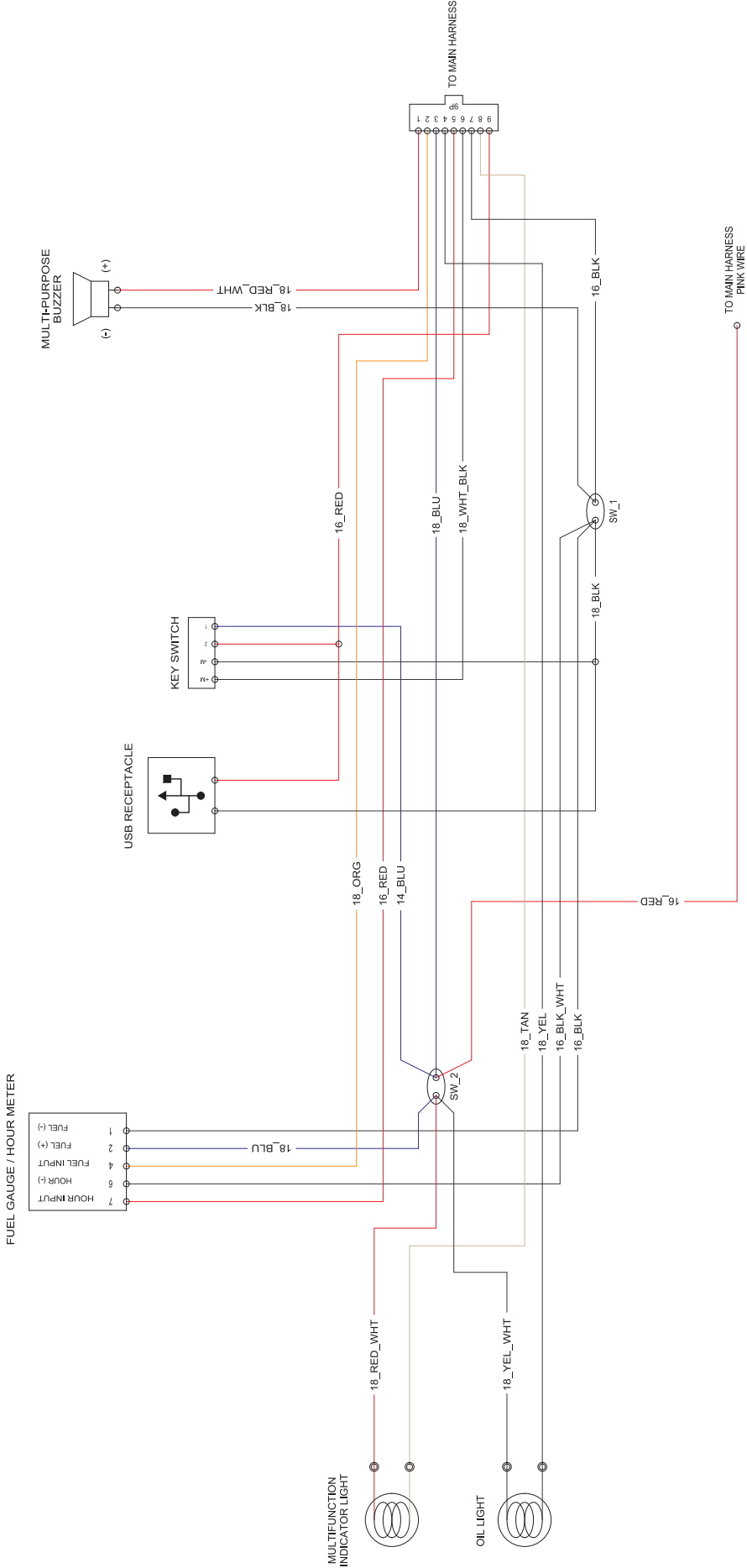
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KOHLER ECH440: MAIN HARNESS



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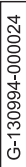
KOHLER ECH440: INSTRUMENT PANEL HARNESS



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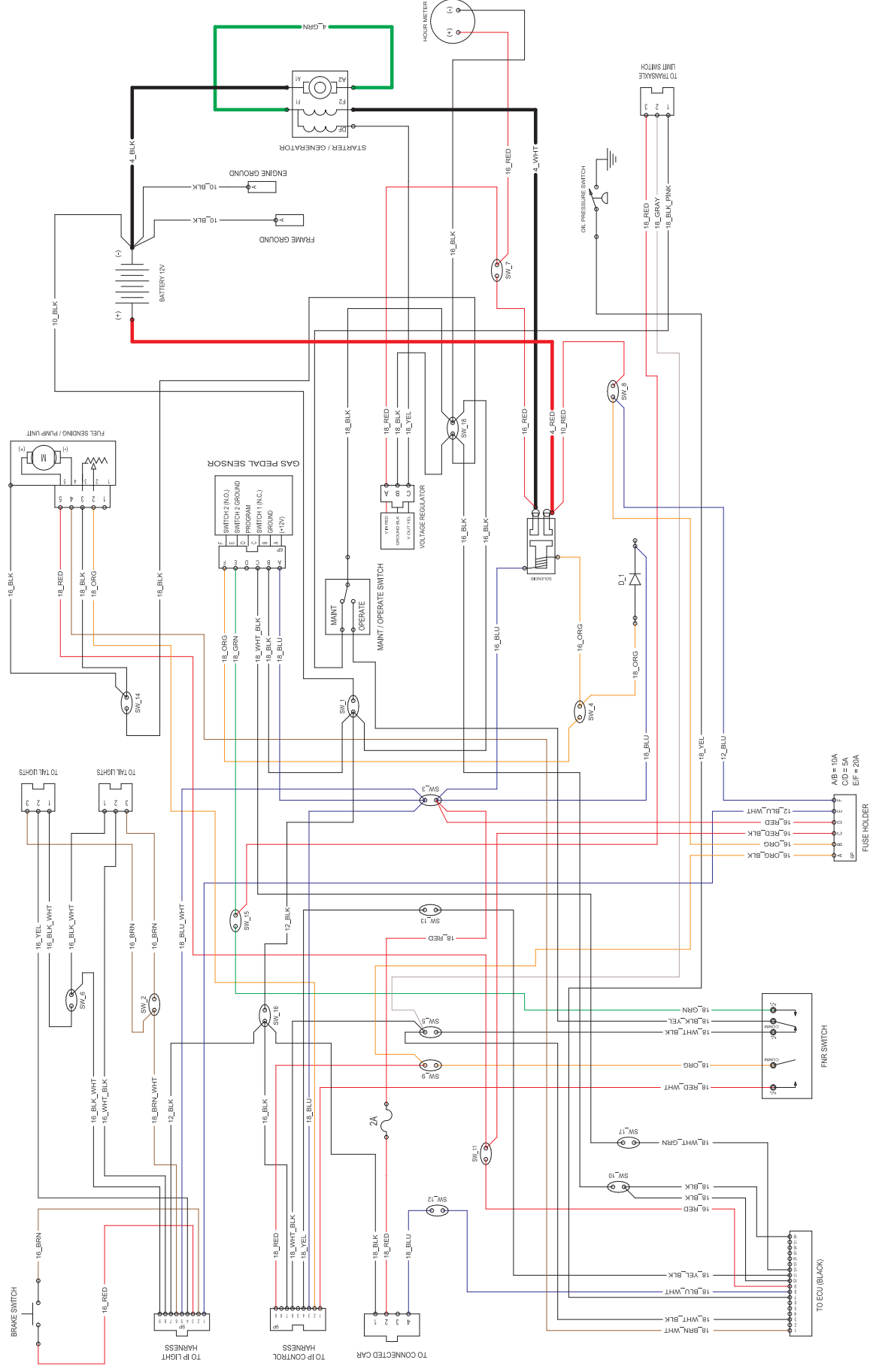
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Club Car



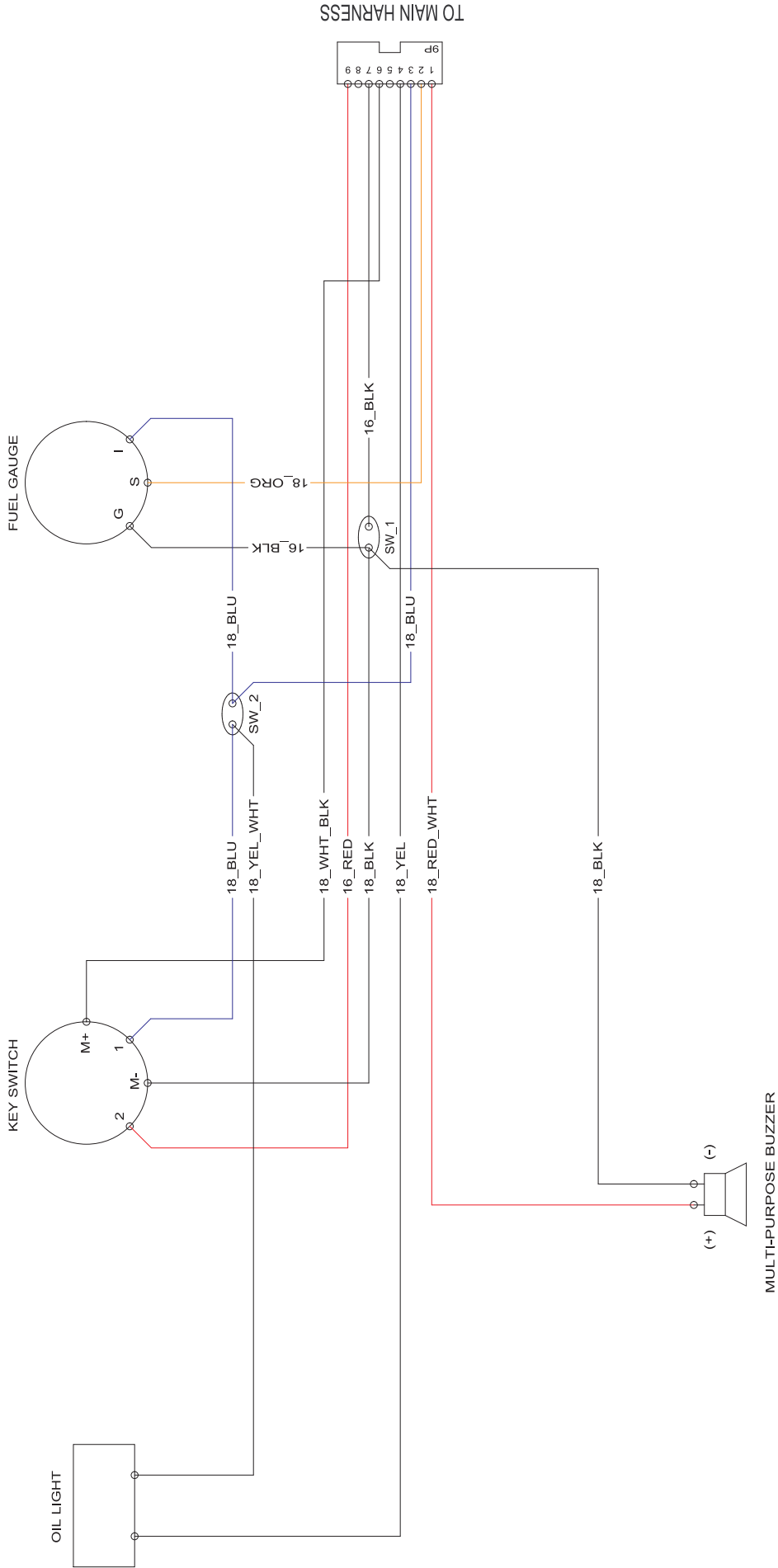
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Club Car



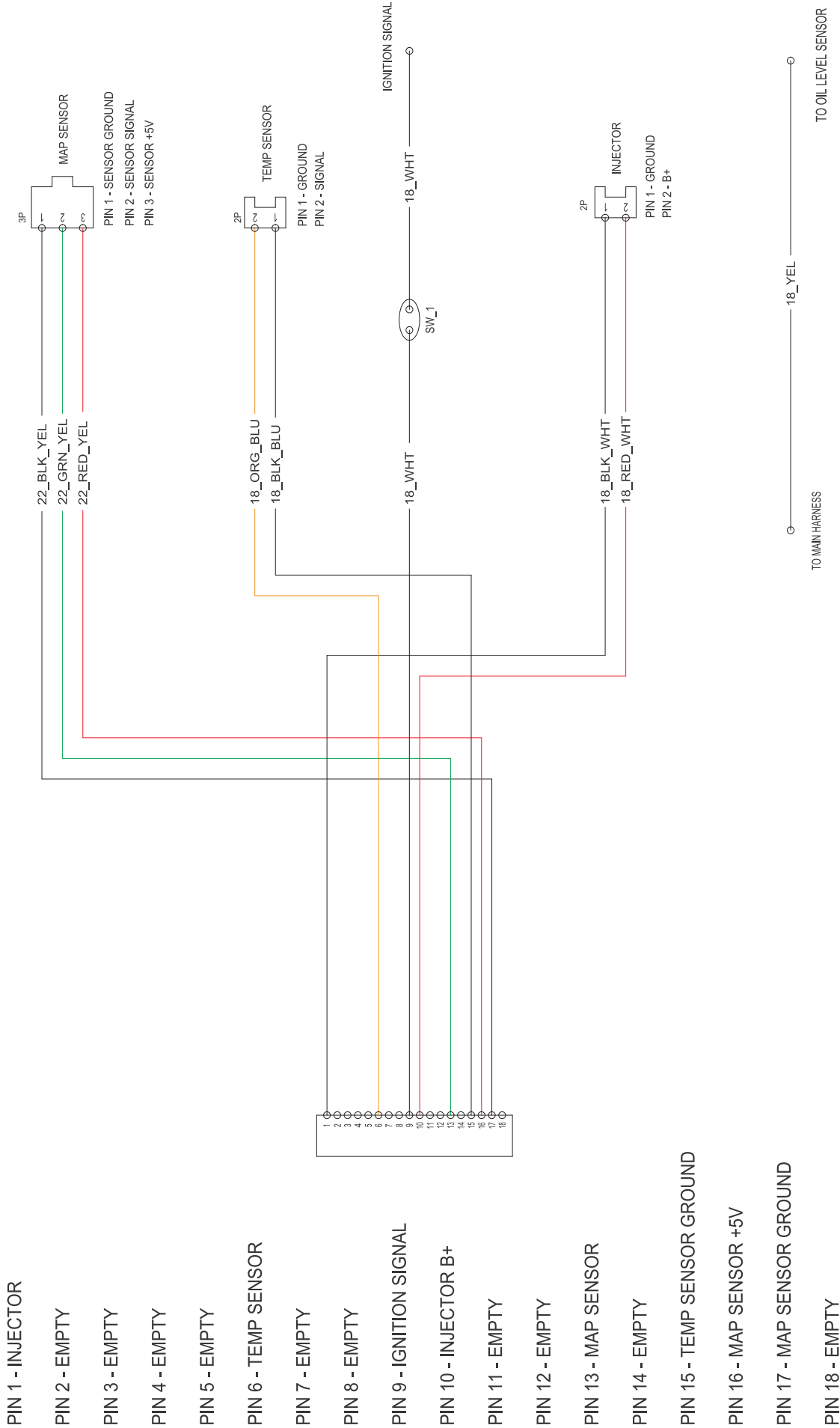
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SUBARU EX-40: INSTRUMENT PANEL DASH HARNESS



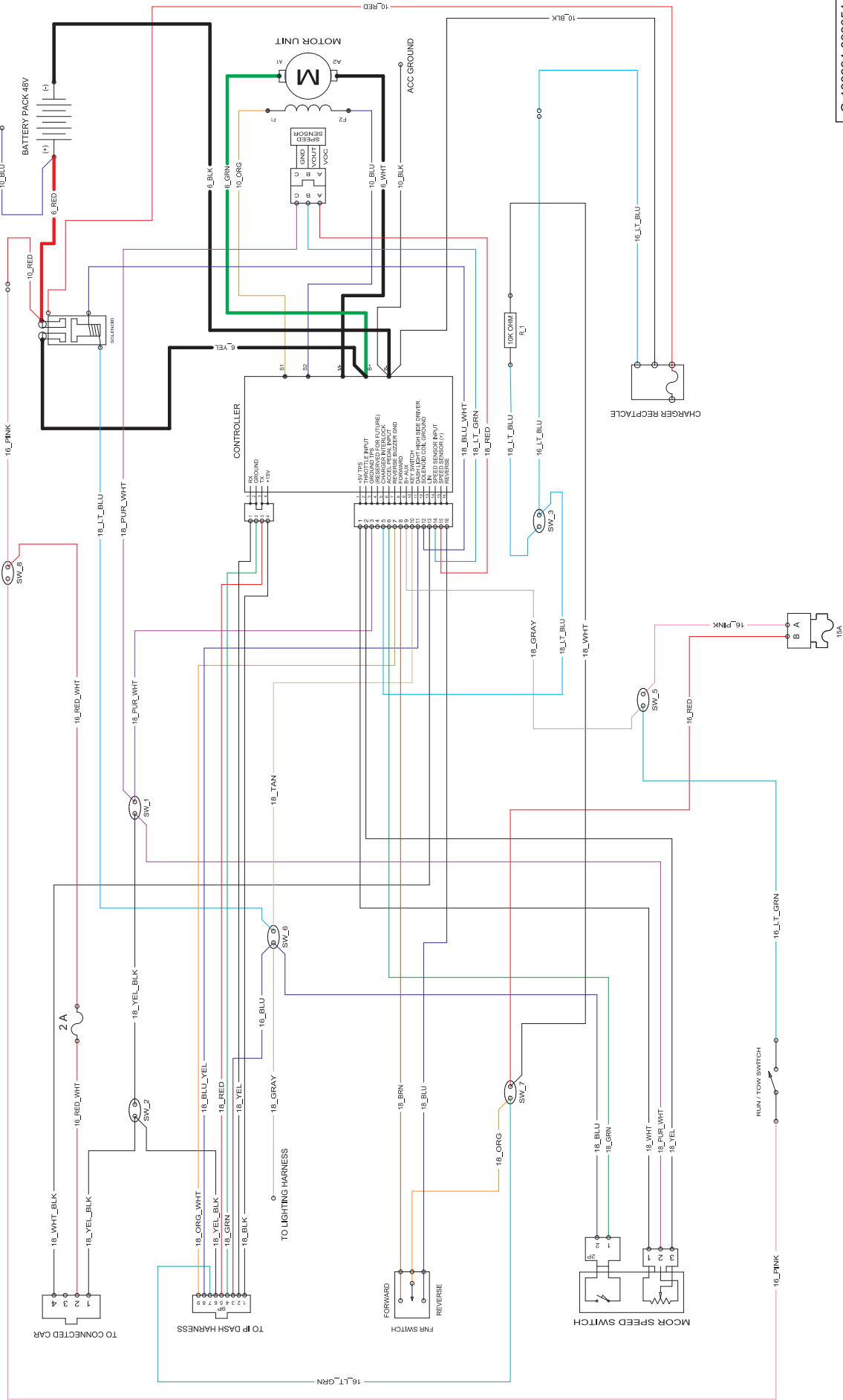
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SUBARU EX-40: ENGINE HARNESS



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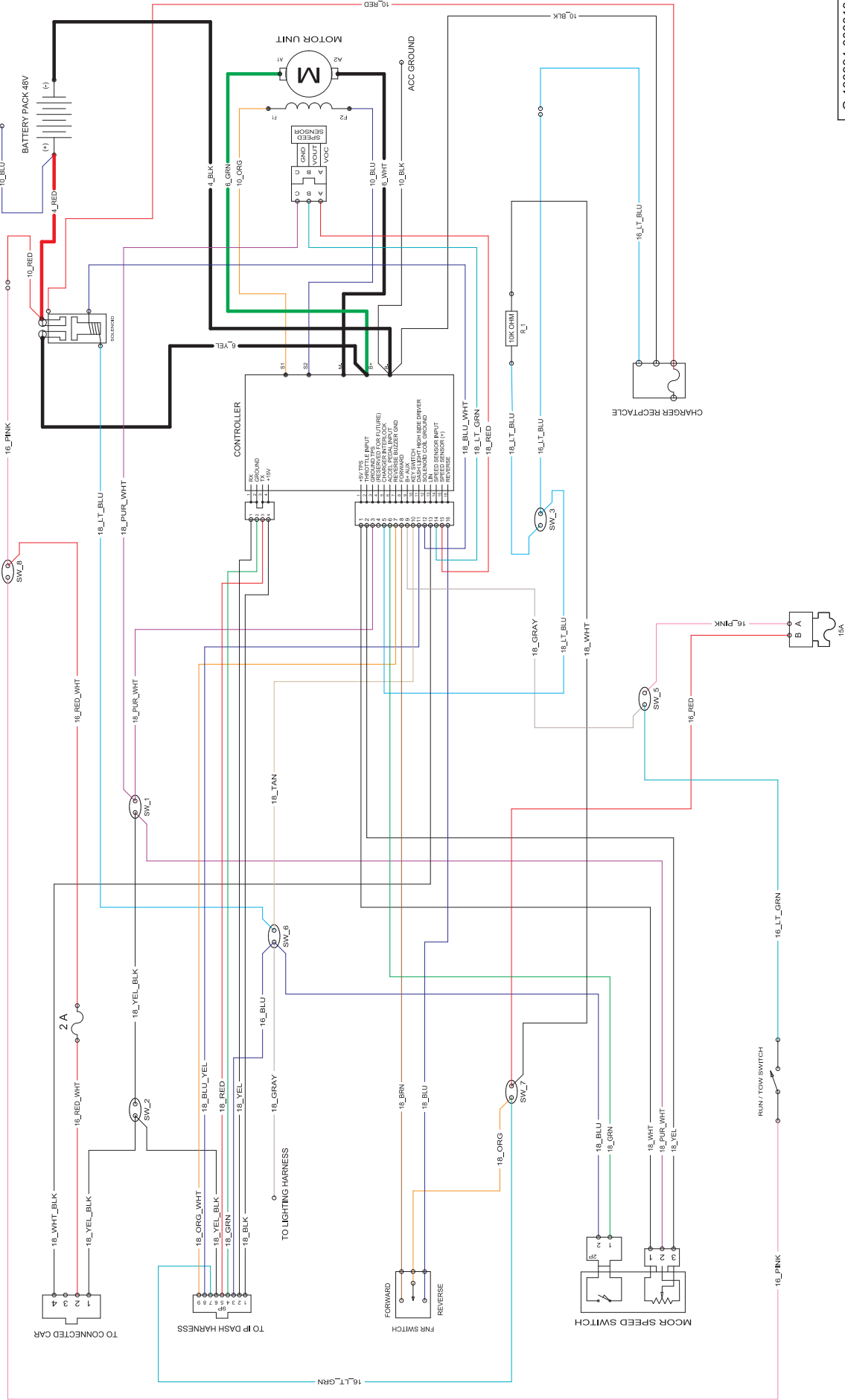
ELECTRIC: TWO PASSENGER MAIN HARNESS



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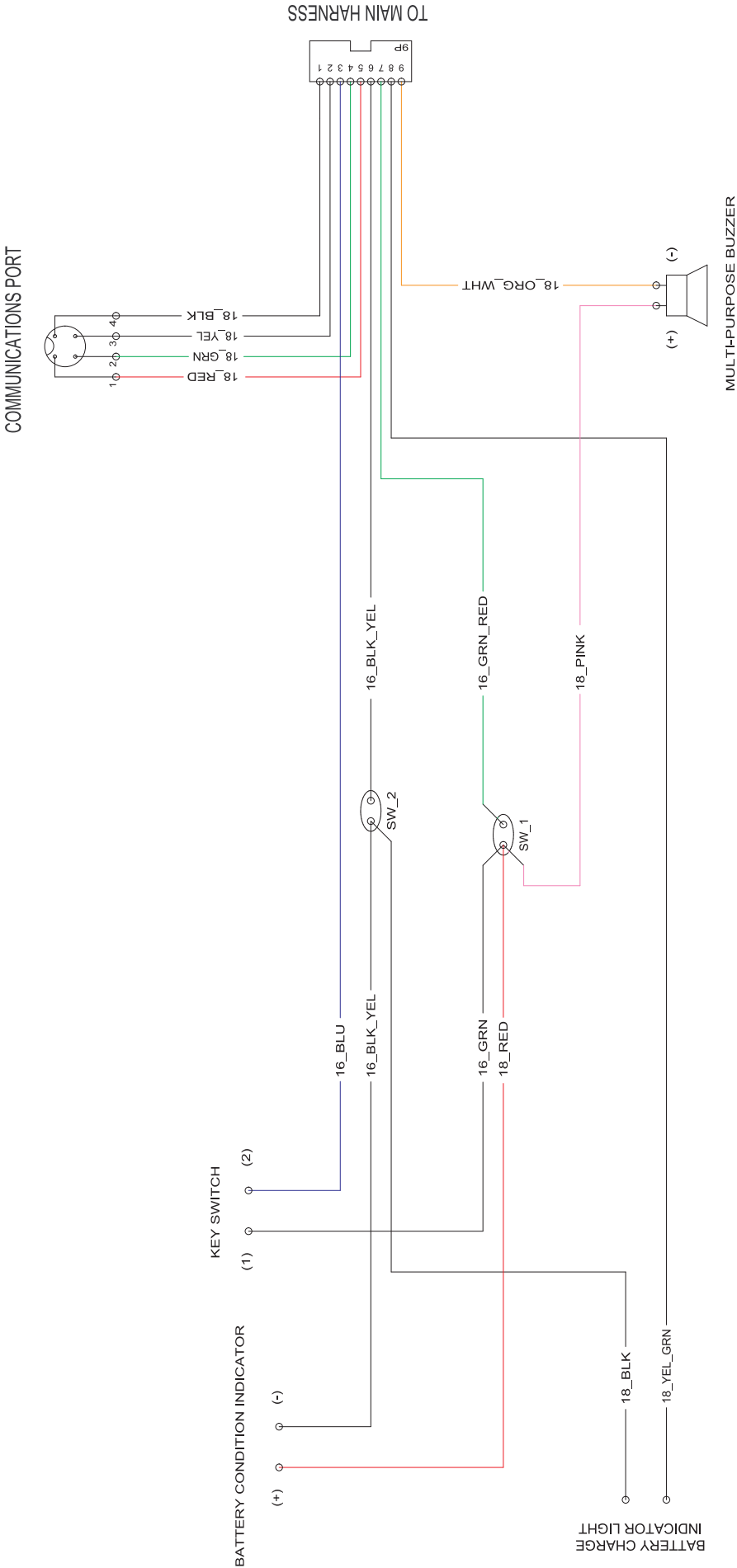
ELECTRIC: FOUR PASSENGER MAIN HARNESS



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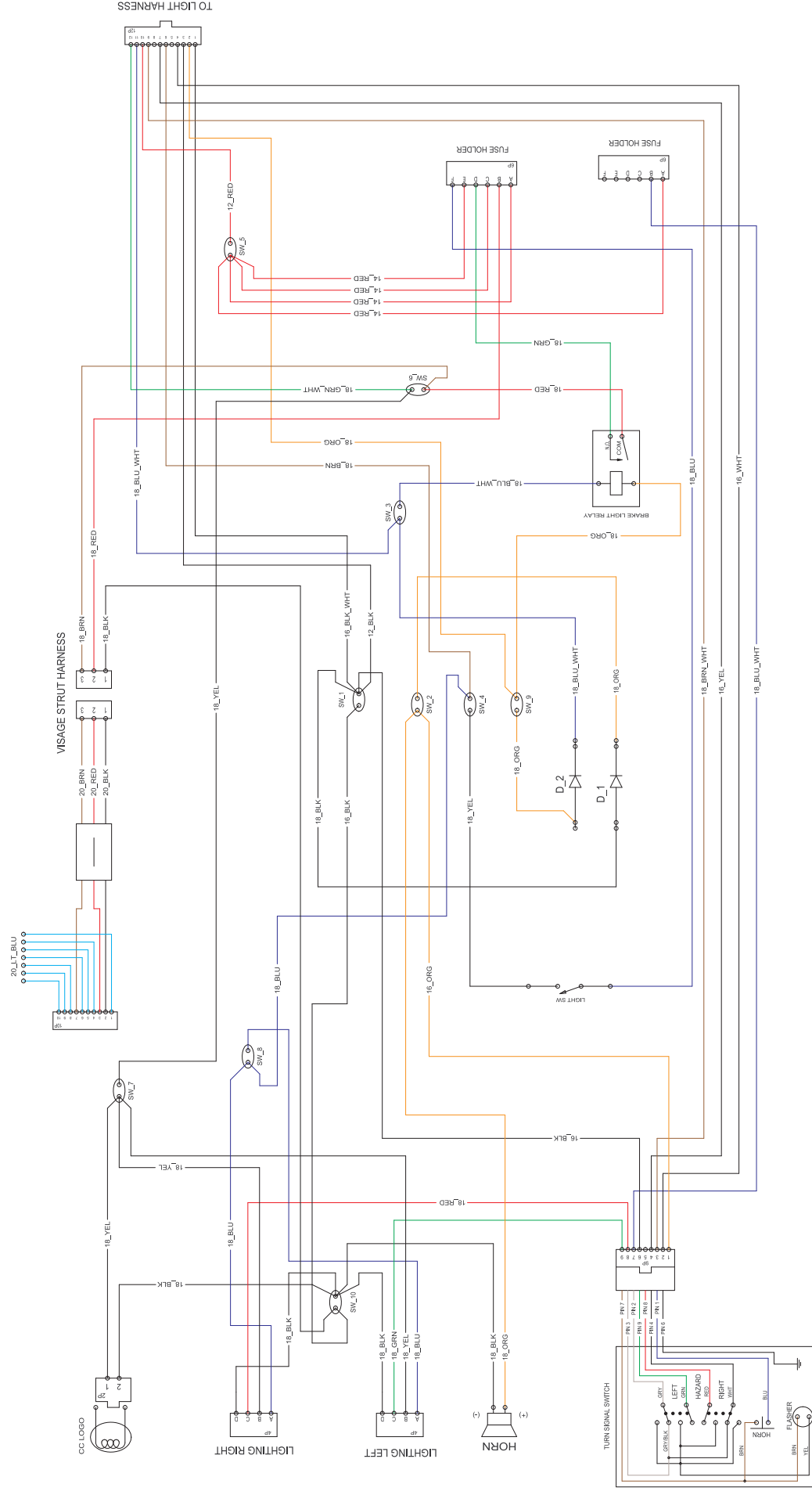
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ELECTRIC: INSTRUMENT PANEL DASH HARNESS



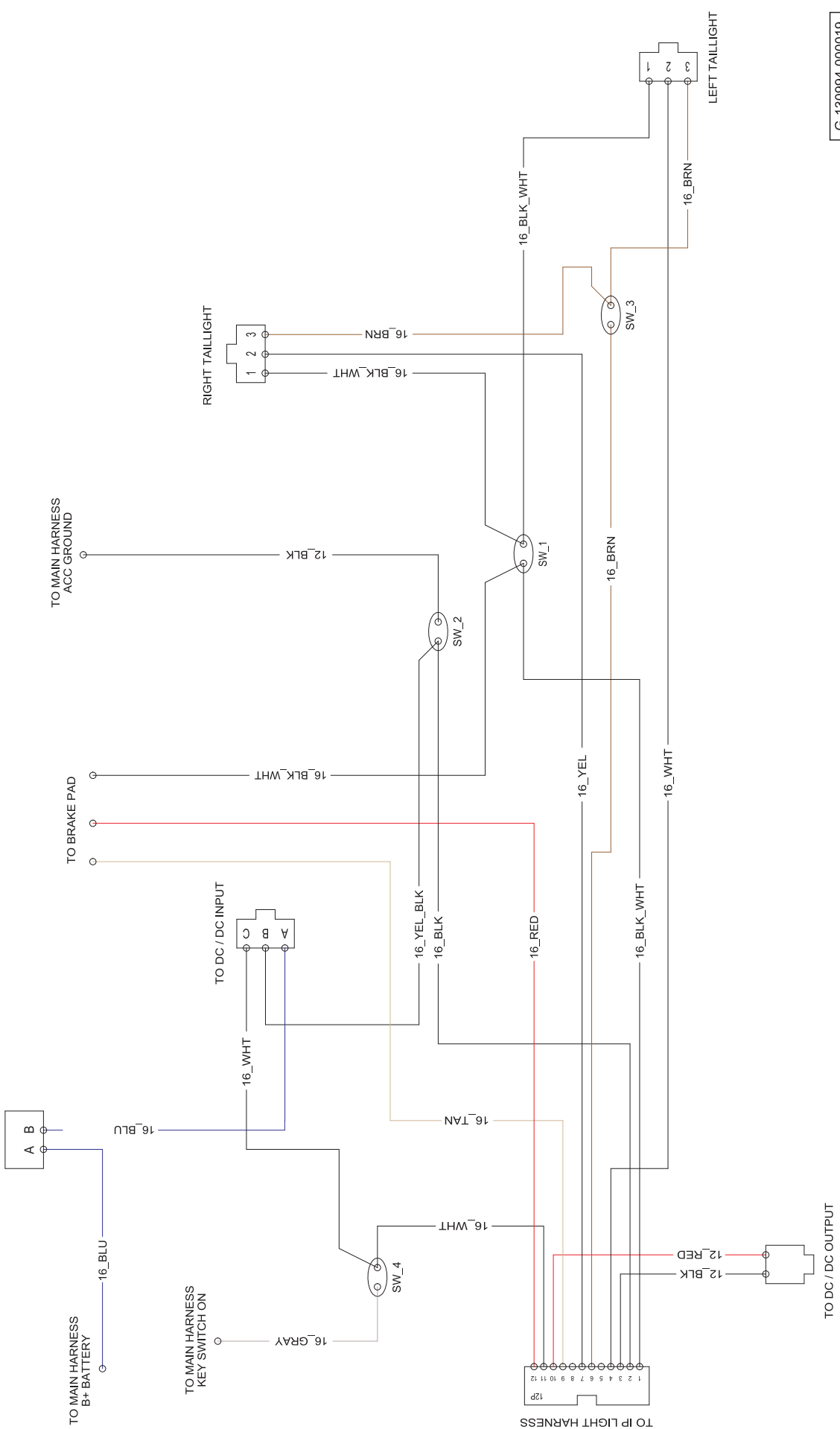
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Club Car



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ELECTRIC: LIGHTING HARNESS



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A

| | |
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NOTES

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