VANGUARD®

REPAIR MANUAL

Vanguard® EFI Diagnostics and Repair

25E300

BRIGGS&STRATTON®

Foreword

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

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

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

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

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

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

Engine Models Covered

This engine repair manual includes the following engine models:

- MODEL 25E300

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

NOTE: Many of the images in this document are representative of the Standard Chore engine. While other engines models may appear somewhat different, unless indicated otherwise, the procedures are the same.

How To Use This Manual

This manual is designed to assist in the diagnostic and troubleshooting process. Troubleshooting of any system follows a similar methodology, in general there are seven steps in the troubleshooting process:

1. Identify the problem. Observe the issue or the symptoms of the issue. Identify the system in which the problem occurs.
2. Create a theory of the probable cause of the problem. Sometimes a problem may have multiple probable causes, in this case, it is necessary to create a plan to test all possibilities to determine the root cause of the problem.
3. Test the theory. Testing individual components as well as systems can provide valuable data that leads to the root cause of the problem.
4. Establish a plan to fix the problem. This may involve a repair, a replacement, or a combination.
5. Execute the plan. This includes repairs or replacements of components as well as any complementary repairs.
6. Verify that the problem is resolved. Sometimes, repairing the first issue will introduce a new issue, so it is important to test the system for full functionality.
7. Document the process. Make sure to record all observations, test data, and repairs.

The manner in which the instructions are used depends upon the task to be performed and the level of disassembly and servicing required.

Safety and General Information

Before starting any troubleshooting process, make sure you are familiar with ALL safety warnings and guidelines in *SECTION 1 - SAFETY AND GENERAL INFORMATION*. The preliminary instructions are designed to prepare you for the diagnostic and repair steps.

Diagnostic Introduction

When diagnosing a specific problem with an engine or engine component, first see *SECTION 2 - DIAGNOSTIC INTRODUCTION*. This section is designed to provide general knowledge of the engine's systems, preliminary diagnostic steps, and the correct way to connect to the engine to retrieve and read diagnostic trouble codes (DTCs).

Troubleshooting Diagnostic Trouble Codes (DTCs)

When diagnosing DTCs, see *SECTION 3 - TROUBLESHOOTING DTCs*. This section of the manual provides information on component locations, DTC definitions, diagnostic steps for each DTC, and action items to help with repairs.

Wire Harness Schematics and Pin-Outs

See *SECTION 4 - WIRE HARNESS SCHEMATICS AND PIN-OUTS* for information related to wire location, connector pin location, wiring schematics, pin-out diagrams and additional information related to testing engine component wiring.

Symptoms and Troubleshooting

This section is designed to be used as a guide for diagnostics on the engine. This section provides potential problem scenarios, potential causes for those problems, and action items to help with the repair.

Removal and Installation

Depending on the service being performed, *SECTION 6 - REMOVAL AND INSTALLATION* provides the procedures to correctly remove and replace a component. The order in which the topics are presented is the order in which assemblies are most easily removed from the engine.

Specifications

This section provides a list of relevant engine specifications for reference. This includes torque specifications, engine parameter specifications and any other specification that is necessary to reference during diagnostic troubleshooting and replacement.

SECTION 1 - SAFETY AND GENERAL INFORMATION

General Safety Messages

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

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

WARNING 

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

WARNING 

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

WARNING 

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

When you add fuel

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

When you start the engine

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

When you operate the equipment

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

When you do maintenance

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

When you move the location of equipment

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

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

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

WARNING 

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

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

WARNING 

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

If you smell gas

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

WARNING 

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

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

WARNING 

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

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

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

WARNING 

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

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

WARNING 

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

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

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

WARNING 

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

Before you make adjustments or repairs:

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

When you check for spark:

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

WARNING 

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

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

WARNING 

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

Fuel Storage

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

SECTION 2 - DIAGNOSTIC INTRODUCTION

Diagnostic Introduction

Preliminary Instructions

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

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

On-Board Diagnostic (OBD) System Check

The basic steps of any diagnosis are as follows:

1. Observe the Malfunction Indicator Lamp (MIL) with engine running. If MIL is illuminated, then current Diagnostic Trouble Codes (DTCs) are present.
2. Read DTC(s) using the Diagnostic Tool.
3. To diagnose system problem(s), proceed to the applicable Diagnostic Table(s) in *SECTION 3 - TROUBLESHOOTING DTCs*.
4. Once the problem is located and corrected through repair or replacement of faulty components, clear DTC(s) using the Diagnostic Tool.
   For information on the location or replacement of specific components, see *SECTION 6 - REMOVAL/ INSTALLATION*.
5. Start and run engine to validate repairs. Observe MIL to verify that no DTCs are set.
6. If no DTCs are set, but engine performance issues exist, see *SECTION 5 - SYMPTOMS AND TROULESHOOTING*.

Diagnostic Trouble Codes (DTCs)

The ECM receives voltage signals from multiple sensors. Each sensor functions within an established set of parameters.

When a malfunction or fault condition occurs, a change in the signal voltage alerts the ECM that the sensor is functioning outside its operating “window,” a DTC is set and stored in ECM memory, and the MIL is illuminated.

A default value temporarily replaces the erroneous sensor value to restore engine performance until the problem is corrected.

Suspect Parameter Number (SPN) and Failure Mode Indicator (FMI)

The J1939 protocol transmits each DTC in a number of parts, two of which are the Suspect Parameter Number (SPN) and the Failure Mode Indicator (FMI).

While the SPN indicates the source of the problem, such as a specific electrical circuit or electrical component, the FMI indicates the type of condition or event that has occurred.

A helpful analogy is to view the SPN as a zip code which brings you to the problem area, while the FMI is the street address. For example, SPN 105 indicates that an issue exists with the Manifold Air Temperature (MAT) Sensor, while FMI 3 indicates that the sensor signal voltage is high/open.

For a list of all DTCs and their respective SPN/FMI components, see *DIAGNOSTIC TROUBLE CODES (DTCs)* in *SECTION 3 - TROUBLESHOOTING DTCs*.

Malfunction Indicator Lamp (MIL)

As a bulb and diagnostic system check, the MIL illuminates at Ignition ON, Engine OFF. When the engine is started, the MIL is extinguished if no current fault condition exists.

If the MIL remains illuminated, it is an indication that a current DTC is stored. If the fault should correct itself, as in an intermittent condition, the MIL is extinguished after a ten second delay. The DTC remains stored in ECM memory as a historic code until cleared by the technician. The MIL does not indicate the existence of only historic codes.

Data Link Connector (DLC)

The DLC provides for direct communication with the ECM. By plugging the Diagnostic Tool into the 6-pin connector in the EFI wire harness, the DTCs stored in ECM memory can be read and cleared. and diagnostic functions can be accessed.

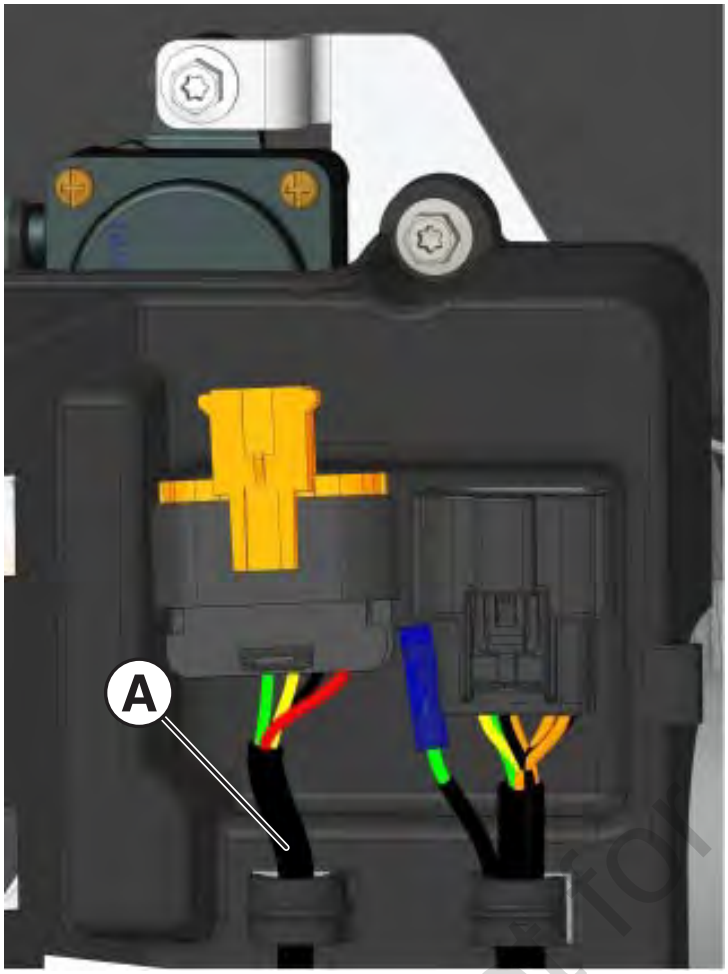
Accessing the DLC requires removal of the engine side cover connector cover and the DLC protective cap. The procedure is as follows:

1. Remove the connector cover from the side cover. Lift the tab of the snap latch (**A**, Figure 1) and rotate the cover away from the engine to remove.

1

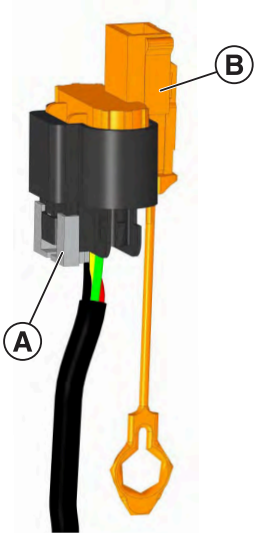
2. Remove the DLC from the wire harness clip (**A**, Figure 2).

2



3. Remove the DLC protective cap. Pull out the locking tab (**A**, Figure 3) and press the connector tab while pulling the protective cap (**B**) away from the DLC.

3



NOTE: Make sure to reinstall the DLC protective cap when diagnostic procedures are concluded.

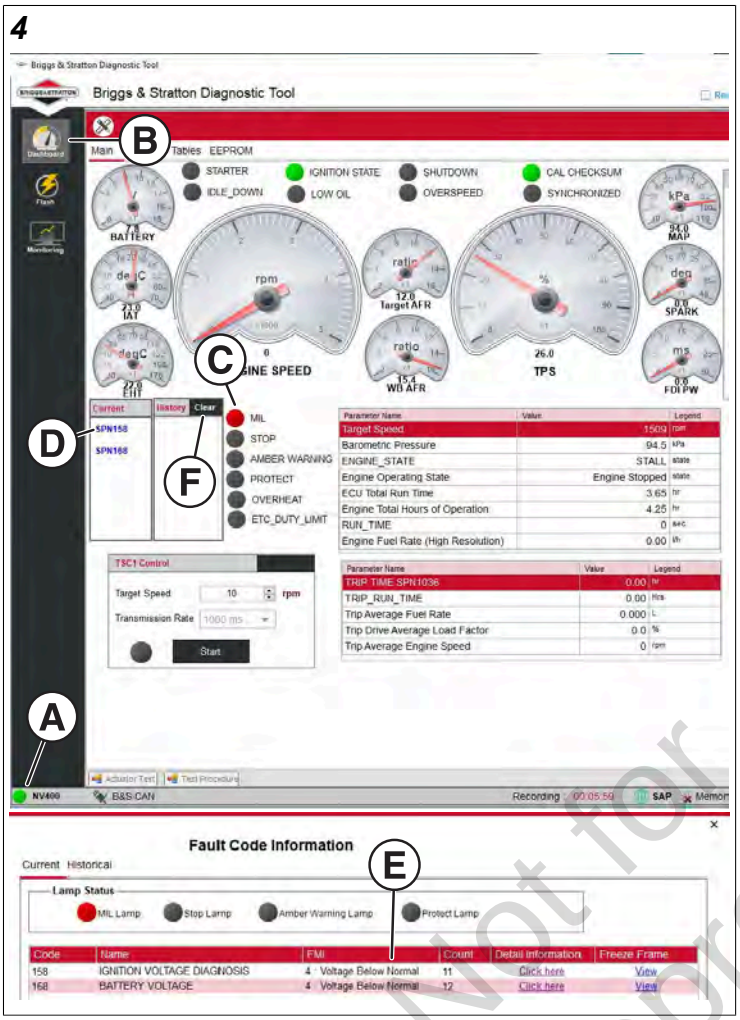
Using the Diagnostic Tool and Software to Read/ Clear DTCs

1. Open the Briggs & Stratton Diagnostic Tool Application by selecting the icon on the desktop.
2. After entering the User Name and Password, click Log In.

NOTE: If this is your first time using the Diagnostic Tool and Software, refer to the *Briggs & Stratton EFI Diagnostic Tool Software User Manual* for installation and setup instructions.

3. Obtain Briggs & Stratton Diagnostic Tool (Part No. 19636) with USB and Interface cables.
4. Connect one end of the USB cable to the Diagnostic Tool and the other end to the USB port on the laptop.
5. Connect one end of the Interface cable to the Diagnostic Tool and the other end to the DLC on the EFI harness.

6. Turn Ignition ON, Engine OFF.
   The Diagnostic Tool can take up to 30 seconds to connect to the engine. Once established, the connection indicator light (**A**, Figure 4) becomes solid green and displays the name of the connected device.



7. Select the **Dashboard** icon (**B**) to view the Dashboard.
8. The **CHECK ENGINE** light (**C**) is red if a current fault code is present.
9. Observe the **Current** codes display. Hover the cursor over the blue hyperlink (**D**) to display a description of the SPN fault code. Click on the hyperlink to read the associated FMI (**E**).
10. Click **Clear** (**F**) to erase both current and historic DTCs.
11. Turn Ignition OFF.
12. Wait ten seconds, and then disconnect the Diagnostic Tool cables and power supply.

NOTE: While the Diagnostic Tool provides "live" data for analysis, it is not a standalone diagnostic tool for resolving DTCs, but must be used in conjunction with the Diagnostic Tables in this manual for the most efficient and effective diagnosis.

Back Probe Connector Terminals

Do not insert probes into terminals on the mating side of any connector. The diameter of the test probes can damage terminals.

1. Obtain a digital volt ohm meter (DVOM) and a back probe wire set.
2. Carefully slide metal pin on probe between the rubber seal and wire insulation on the back side (wire end) of the connector.
3. Gently push the pin in until it stops. Stop pushing when the pin "bottoms out," or when the plastic sheath is very close to the connector housing.

   DO NOT force the pin into the connector as terminal and/or probe pin damage can occur. Probe travel may be stopped by contact with insulation or core crimps. Try again after removing and re-positioning probe pin.

   IMPORTANT:

   - Use care to avoid deforming connector terminals, either by forcing the probe too far into the cavity or by using a probe that is too large. If terminal damage is suspected, test for proper terminal contact.
   - A deformed terminal can cause a poor connection resulting in intermittent problems or even complete component failure. Do not use paper clips or other substitute devices as they also can damage terminals.
   - Do not probe through connector seals, wire insulation, secondary ignition wires, boots, etc. Damage can occur that is not readily apparent and tiny holes can result in water intrusion, which leads to corrosion and eventual component failure.

Avoid ECM Damage

A surge in voltage, current or both, is called a voltage spike. Voltage spikes can cause major damage to the ECM.

To avoid ECM failure due to accidentally induced voltage spikes, always observe the following precautions:

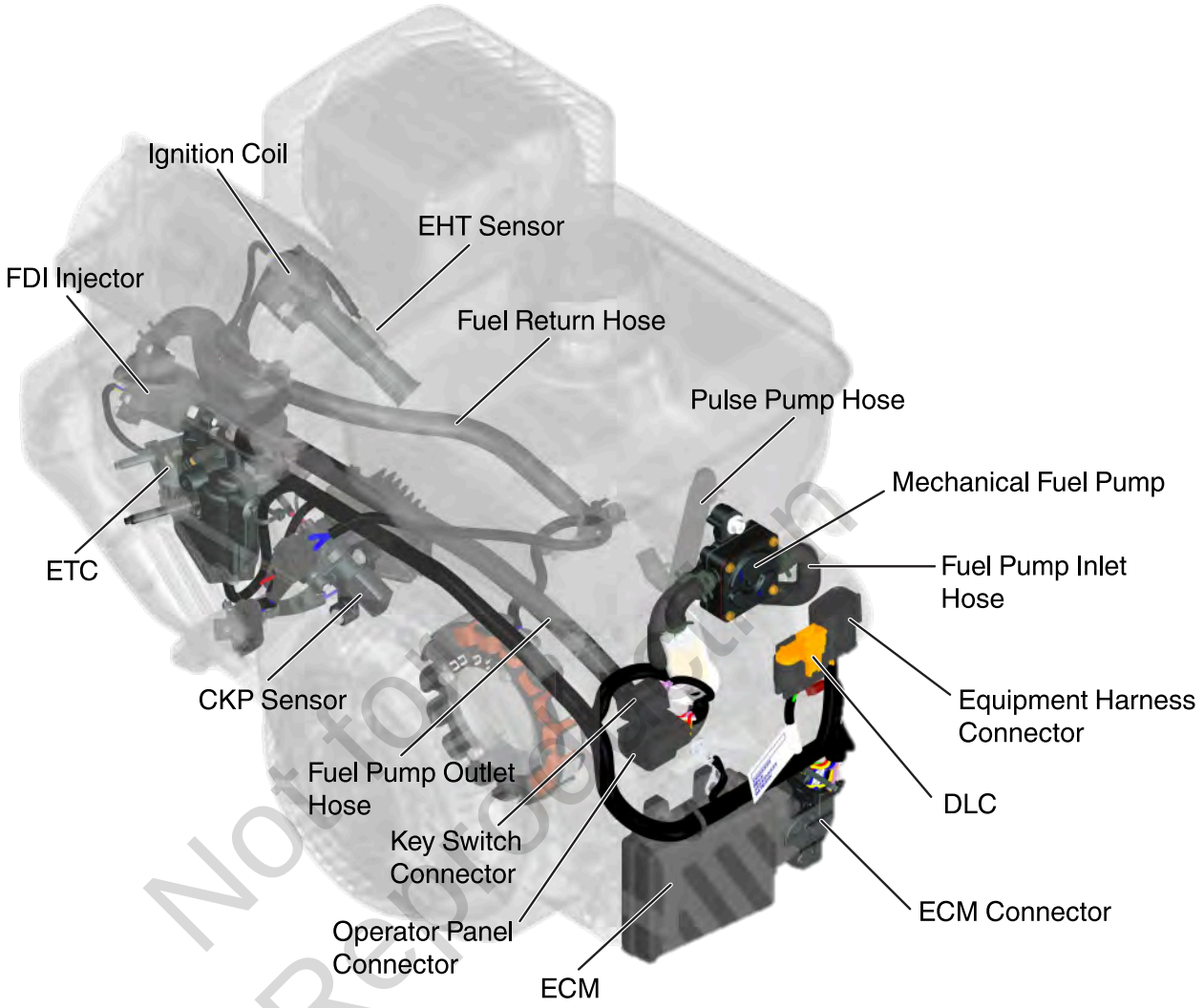
- Do not start engine if battery cable connections are loose.
- Do not use a battery charger to start engine.
- Turn Ignition OFF before disconnecting and/or connecting battery cables.
- When disconnecting battery, always disconnect battery negative (-) cable first.
- When connecting battery, always connect battery positive (+) cable first.
- When charging battery, turn Ignition OFF and remove battery negative cable (black) from battery negative (-) terminal.
- If electric welding on vehicle, remove battery negative cable (black) from battery negative (-) terminal, and disconnect the ECM electrical connector(s).

SECTION 3 - TROUBLESHOOTING DTCs

Diagnostic Trouble Codes (DTCs)

SPN	Component	FMI	Description
51	Throttle Position Sensor (TPS)	2	Intermittent Fail
		3	Signal Voltage High
		4	Signal Voltage Low/Open
91	Analog Speed Lever	3	Signal Voltage High
		4	Signal Voltage Low/Open
98	Low Oil Level Sensor	1	Low Oil Level Error
102	Manifold Absolute Pressure (MAP) Sensor	3	Signal Voltage High
		4	Signal Voltage Low/Open
105	Intake Air Temperature (IAT) Sensor	2	Intermittent Fail
		3	Signal Voltage High/Open
		4	Signal Voltage Low
110	Engine Cylinder Head Temperature (EHT) Sensor	2	Intermittent Fail
		3	Voltage High/Open
		4	Voltage Low
158	Ignition Key Voltage	3	Voltage High
		4	Voltage Low
168	Battery Voltage	3	Voltage High
		4	Voltage Low
190	Engine Overspeed Detection	15	Over Speed Detected
633	Vapor Detection	8	Vapors Detected In FDI During RUN STATE
		11	Vapors Detected In FDI During CRANKING STATE
636	Crankshaft Wrong Tooth Number	2	Not Enough Teeth Detected
		8	Additional Tooth Detected
637	Missing Crank Sensor (CKP)	7	Missing Crank Sensor Signal
639	CAN Bus Offline	19	Data Error
651	Fuel Injector #1	3	Voltage High/Open
		4	Voltage Low
818	Voltage Protection	3	5V Supply Shorted High
		4	5V Supply Shorted Low
		16	Over Temperature
1110	Engine Over-Temperature	0	Engine Cylinder Head Over Maximum Temperature For Maximum Allowed Time
1268	Cylinder #1 Ignition	3	Circuit Shorted High/Open
		4	Circuit Shorted Low
1569	Engine Over-Temperature	16	Cylinder Head Over Maximum Temperature While Running
5419	Electronic Throttle Control (ETC)	3	ETC Driver Pin 1 and/or Pin 2 Circuit Shorted High
		4	ETC Driver Pin 1 and/ or Pin 2 Circuit Shorted Low
		5	ETC Driver Circuit Open
		6	ETC Driver Shorted Between Pin 1 & 2
		8	Pulse Width Modulation Out of Range
		15	ETC Driver Over Temperature WARNING
		16	ETC Driver Over Temperature
6805	Engine Over Temperature	16	SPN 6805 Appears With SPN 1569. SPN 6805 Will Trigger an Engine Speed Derate.
7753	Starter Motor	3	Input Signal Circuit Shorted High

Model 25E300 EFI Component Locations



Preliminary Instructions

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

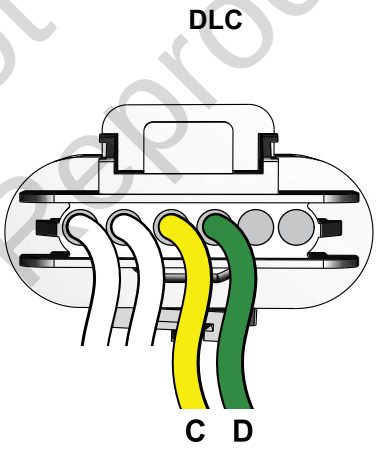
ALWAYS wear safety glasses and gloves while performing any diagnostic, maintenance or repair operation.

CAN BUS Troubleshooting

Troubleshooting DTCs may not always get to the real source of the problem, as there can be instances where the problem originates with the CAN bus. Bad connections can result in faulty communications with the ECM resulting in a faulty diagnosis.

Check Voltages

Step	Action
1	1. Turn Ignition OFF. 2. Back probe CAN Hi terminal C (Yellow wire) at the DLC. 3. Connect terminal C back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to ground. 5. Turn Ignition ON, Engine OFF. 6. Compare voltage to table below.
2	1. Turn Ignition OFF. 2. Back probe CAN Lo terminal D (Green wire) at the DLC. 3. Connect terminal D back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to ground. 5. Turn Ignition ON, Engine OFF. 6. Compare voltage to table below.



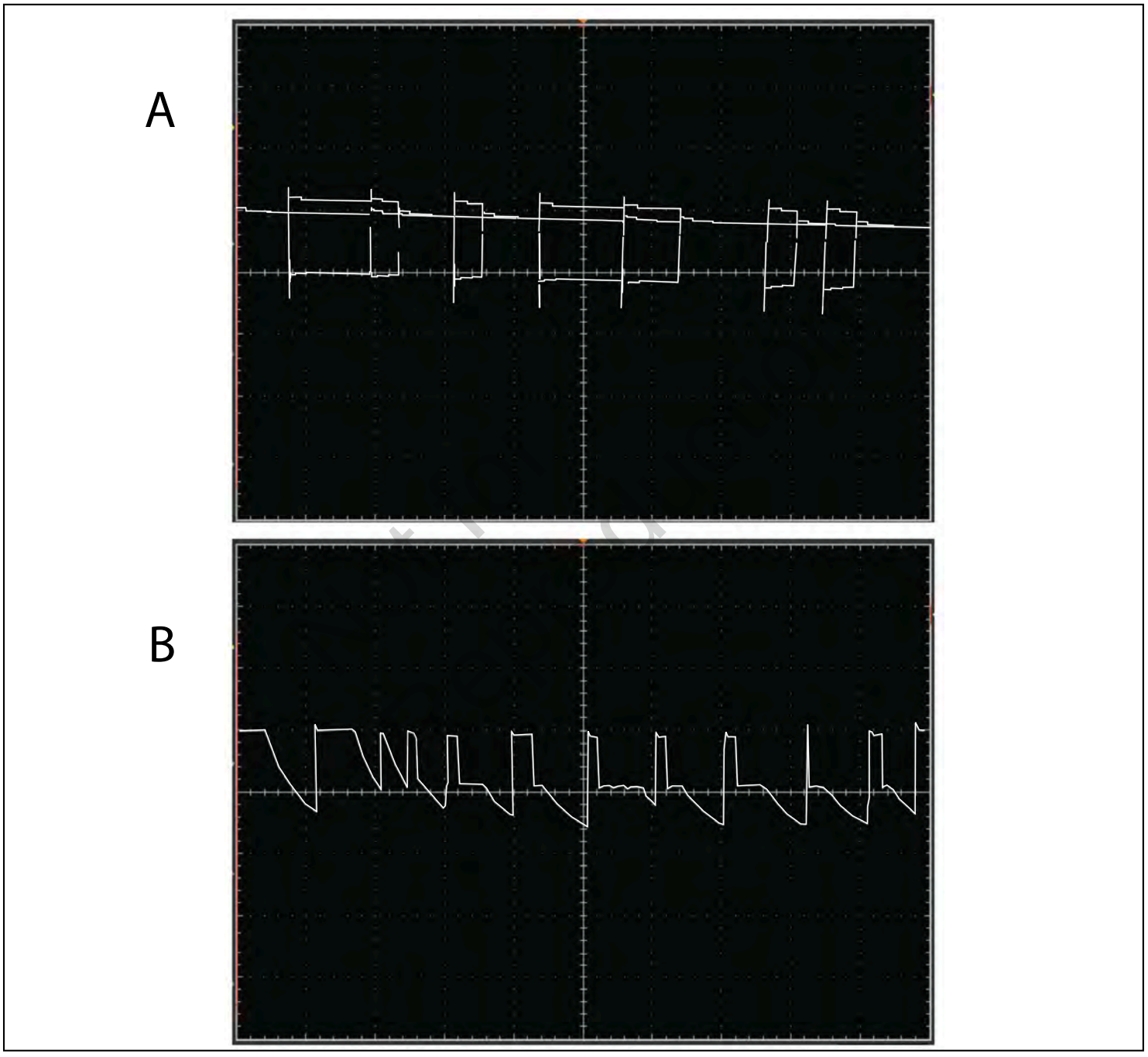
Can Bus Circuits	Sleep	Idle (Recessive) KOEO	Active Bus	CAN Lo Short to Ground	CAN Hi Short to Ground	CAN Lo Short to Power	CAN Hi Short to Power	CAN Hi Short to CAN Lo
CAN Lo (-)	0 VDC	2.5 VDC	1.5 VDC – 2.5 VDC	0 VDC	0-0.5 VDC	5-12 VDC	Below 0.75 VDC	2.45 VDC
CAN Hi (+)	0 VDC	2.5 VDC	2.5 VDC – 3.5 VDC	0-0.5 VDC	0 V	Below 0.75 VDC	5-12 VDC	2.45 VDC
Resistance Test	120 Ohms: Between both CAN HI and LO							

Check Waveforms

It is generally recommended that an overall bus check be performed using an oscilloscope. An inexpensive oscilloscope, and a simple multi-meter using the ohmmeter option can give valuable information on the health of the CAN bus.

The CAN electrical signals can be viewed by connecting the oscilloscope to terminal C (CAN Hi) and terminal D (CAN Lo) on the DLC. Healthy CAN signal waveforms will appear similar to that shown in **A** of the figure below. A CAN bus with a corrupted signal is shown in **B**.

5



Test Procedures

The Diagnostic Tool can be used to perform a series of actuator tests to check the functionality of specific engine components. These can only be done with the engine not running. These actuator tests confirm the functionality of the specific component actuators.

1. Connect the Diagnostic Tool and proceed to the Dashboard. See *SECTION 2 - DIAGNOSTIC INTRODUCTION, Using the Diagnostic Tool to Read/Clear DTCs,* steps 1-12.
2. Select the Actuator Test tab (**A**, Figure 6) in the lower left corner of the screen as shown in the inset of the figure below.
3. To ascertain the general health of the engine, check the box in the header (**B**) to the left of Test Name. This action will cause all the succeeding boxes to be checked. Press Start (**C**) to automatically perform each test in the sequence shown.

   If addressing one particular SPN, only check the box of the applicable test, as follows:

DTC	Test
SPN 651	FDI Actuation Test
SPN 1268	Ignition Coil Spark Test
SPN 51 and 5419	Electronic Throttle Sweep Test
	MIL Lamp Test
SPN 98	Oil Lamp Test
SPN 7753	Starter Motor Actuation Test

4. When the test procedure is finished, the system will display either Pass or Fail in the Test Status column (**D**). If the test passes then no problem currently exists. If the test fails, proceed to the appropriate diagnostic section for more information.

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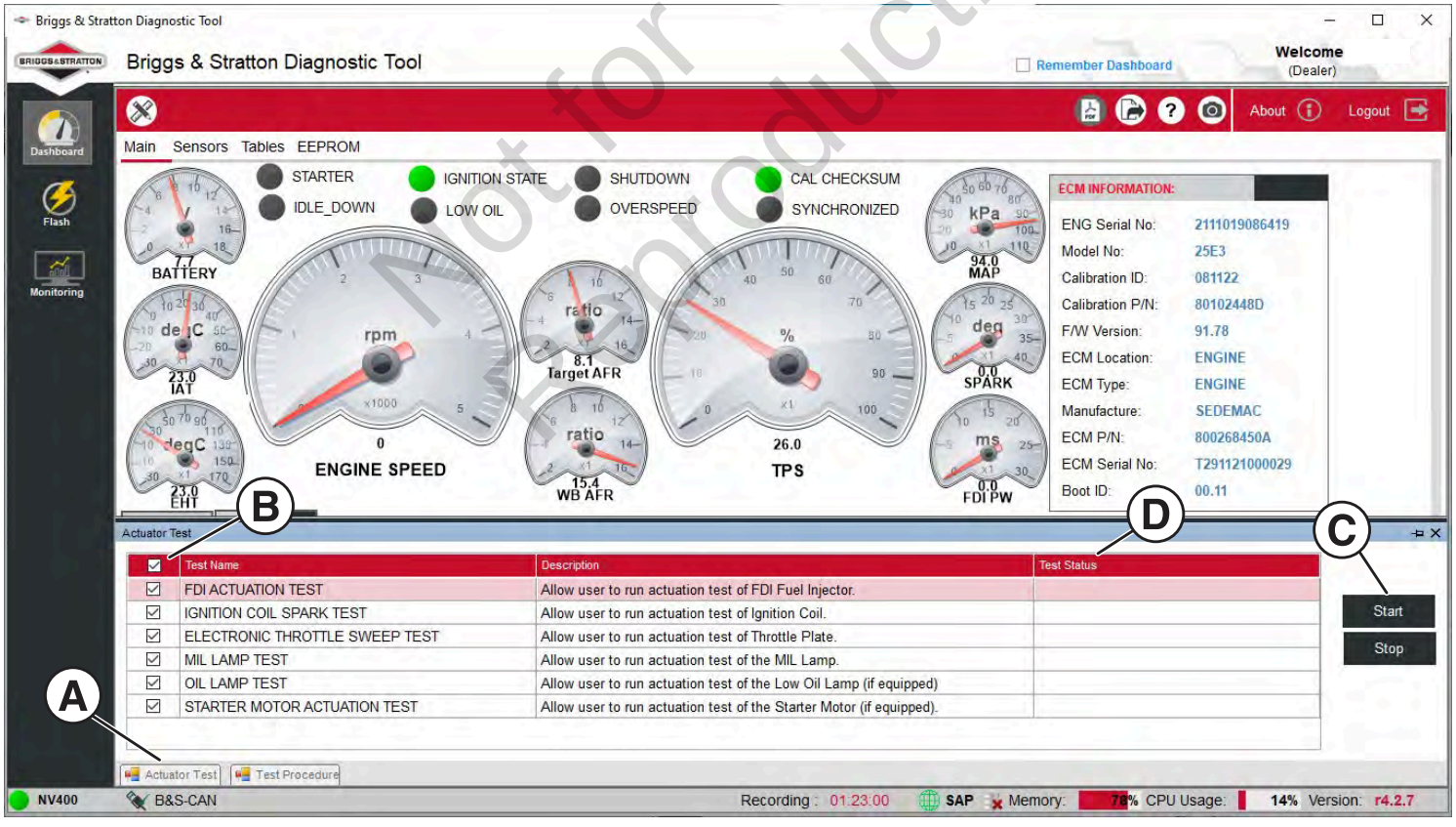


Verify Engine Control Module (ECM) Powers Up

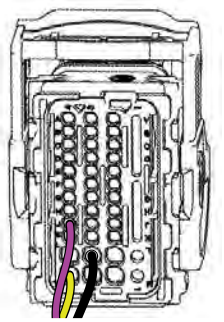
Circuit Description - ECM Power

Since all EFI components are dependent on proper operation of the ECM, any diagnosis must include checking ECM power and ground. Remove and clean battery terminals. While terminals may appear clean, corrosion on the inner surfaces can cause a poor connection to ground.

Check ECM Power and Ground

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. See *ECM Connector Loom Cover Removal*. See Figure 7. 3. Back probe terminal J4 (Violet wire) of ECM connector. 4. Connect terminal J4 back probe to red meter test lead on DVOM. 5. Connect black meter test lead on DVOM to a known good ground. 6. Set DVOM to read volts DC. 7. Turn Ignition ON, Engine OFF. 8. Observe voltage on DVOM. 9. Is reading 12.2-14.5 volts DC?	Go to step 2.	Look for open or short to ground in battery (B+) feed circuit. Perform visual and continuity check of 2 amp Ignition fuse (Grey) on the operator panel. Perform visual and continuity check of 10 amp main fuse (Red) on the operator panel.
2	1. Turn Ignition OFF. 2. Remove probe from terminal J4, and back probe terminal M4 (Yellow wire) of ECM connector. 3. Connect terminal M4 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to a known good ground. 5. Turn Ignition ON, Engine OFF. 6. Observe voltage on DVOM. 7. Is reading 12.2-14.5 volts DC?	Go to step 3.	Look for open or short to ground in ignition feed circuit.
3	1. Turn Ignition OFF. 2. Remove probe from terminal M4, and back probe terminal L3 (Black wire) of ECM connector. 3. Connect terminal L3 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to a known good ground. 5. Set DVOM to read resistance. 6. Observe reading on DVOM. 7. Is resistance 1.0 ohm or less?		Look for open or short in ECM ground circuit.

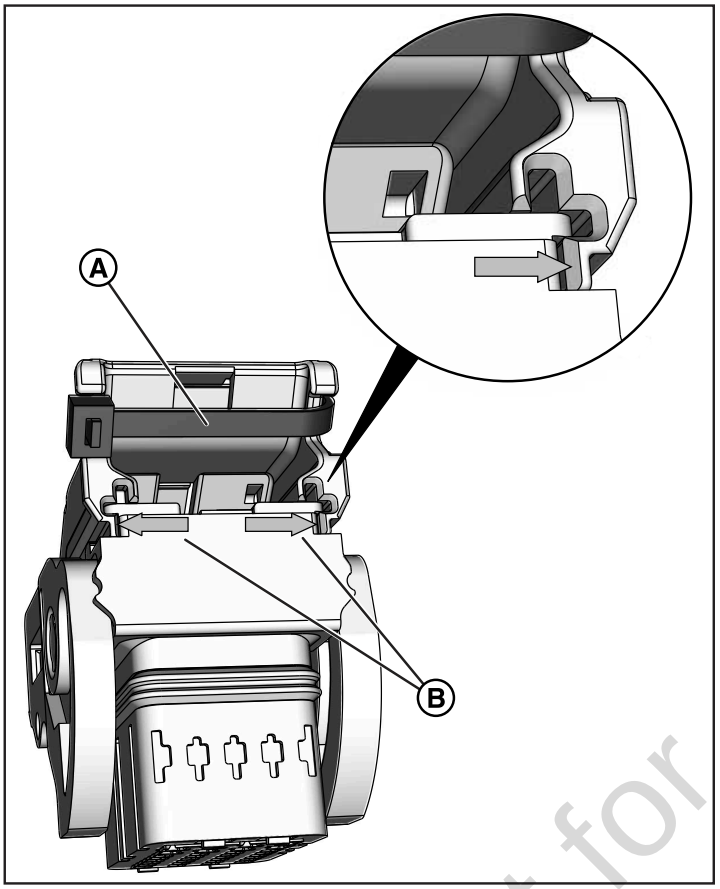
NOTE: The fuse panel is located under a protective rubber cap on the back side of the operator panel. See *SECTION 6 - REMOVAL AND INSTALLATION - Operator Panel* for removal procedure.



ECM Connector Loom Cover Removal

1. Cut and remove cable strap (**A**, Figure 7).

7



2. Lightly push loom cover towards terminal end of connector.
3. While maintaining light pressure on the loom cover, use a small flat blade screwdriver to push latch (**B**) on each side of terminal end of connector outward away from connector body. Do not release pressure on the loom cover or latches will close. Loom cover will slide off connector body after the second latch is released.

SPN 51 Throttle Position Sensor (TPS)

Circuit Description

The TPS is used for engine control and governing. The TPS monitors and controls the throttle position under all operating conditions.

Whenever any SPN 51 FMI is detected, the power to the Electronic Throttle Control (ETC) motor is removed and the ETC is disabled. When this occurs, the throttle plate returns to its "rest" position and a lower RPM limiter is engaged to allow the engine to continue to operate, with a low idle speed.

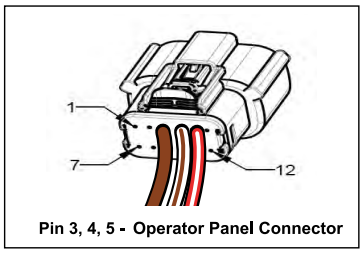
Possible FMIs - SPN 51

The possible FMIs for SPN 51 are as follows:

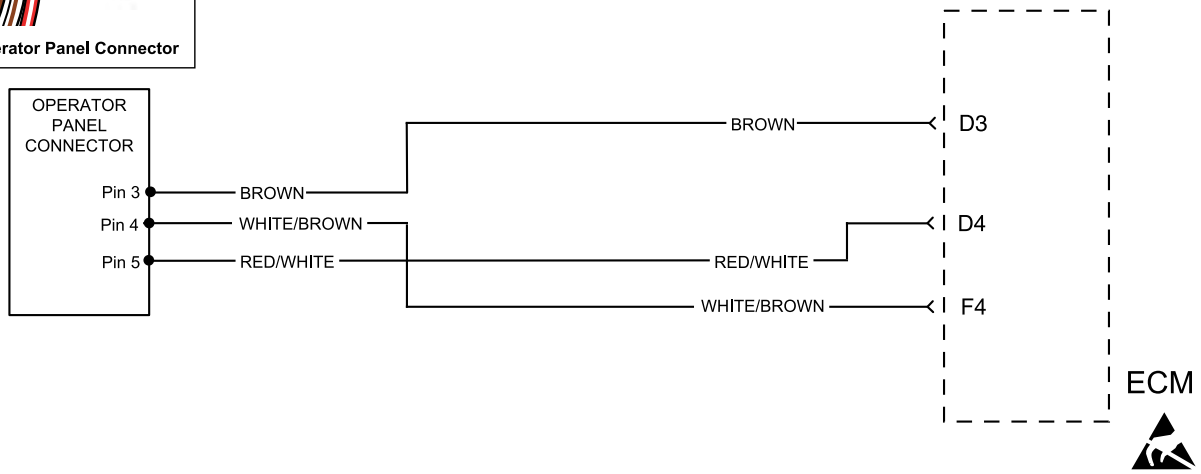
FMI	Description
2	Intermittent Fail
3	Signal Voltage High
4	Signal Voltage Low/Open

NOTE: The TPS is an integral part of the ETC, which also consists of the ECM, MAP sensor, MAT sensor, throttle body, and stepper motor. The ETC is not serviceable and can not be physically tested. If any SPN 51 FMI is present, see *TEST PROCEDURES* in this section for information on performing the Electronic Throttle Sweep Test. Replace ETC if test fails.

SPN 91 Speed Lever



Pin 3, 4, 5 - Operator Panel Connector



Circuit Description

The ECM provides 5 volts power to the throttle on the equipment, vehicle or to the speed control lever on the engine operator panel. The throttle then returns a voltage to the ECM that is interpreted as a commanded engine speed. If the voltage exceeds 4.9 volts DC, or drops below 0.1 volts DC, the appropriate FMI will set.

NOTE: The engine will default to minimum target engine speed if SPN 91 fault is active.

Possible FMIs - SPN 91

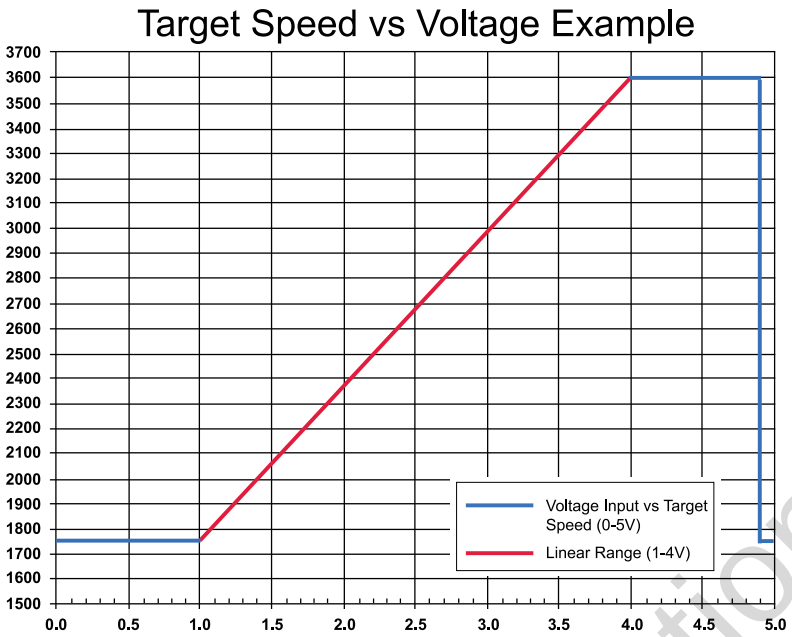
The possible FMIs for SPN 91 are as follows:

FMI	Description
3	Signal Voltage High
4	Signal Voltage Low/Open

Speed vs Voltage Table

8

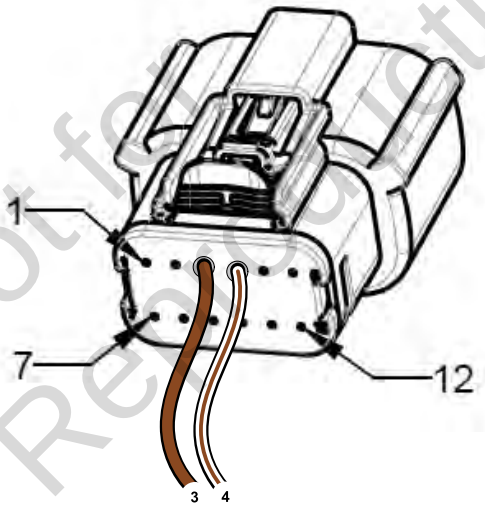
	MIL Range		Idle Range		Target Speed	High Range		MIL Range	
Enter Target Speeds	1750	1750	1750	1750	3200	3600	3600	1750	1750
Enter Idle and High Voltages	0	0.1	0.1	1	3.351	4	4.9	4.9	5
Target Resistor Values (Ohm)			50		508.20	1200			
Calculated Voltage Out (V)			0.83		3.351	4.14			



Input (V)	Commanded Throttle (%)
0.00	Fault Condition
0.10	0%
1.00	0%
1.75	25%
2.50	50%
3.25	75%
4.00	100%
4.90	100%
5.00	Fault Condition

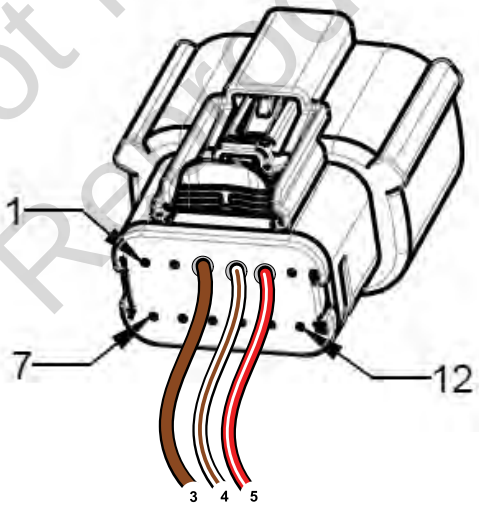
SPN 91, FMI 3: Signal Voltage High

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Back probe terminal 4 (White/Brown wire) on engine side of the operator panel connector. 3. Connect terminal 4 back probe to red meter test lead on DVOM. 4. Back probe terminal 3 (Brown wire) on engine side of the operator panel connector. 5. Connect terminal 3 back probe to black meter test lead on DVOM. 6. Set DVOM to read volts DC. 7. Turn Ignition ON, Engine OFF. 8. Move the throttle control to low speed and take note of the voltage reading. Voltage reading should decrease. 9. Move the throttle control to high speed and take note of the voltage reading. Voltage reading should increase. 10. When the throttle was moved to high speed was the voltage greater than 4.9 VDC?	Look for throttle control problems on the operator panel and/or equipment side.	No problem currently exists. Clear codes. While monitoring voltage, try to duplicate failure by performing multiple throttle sweeps.

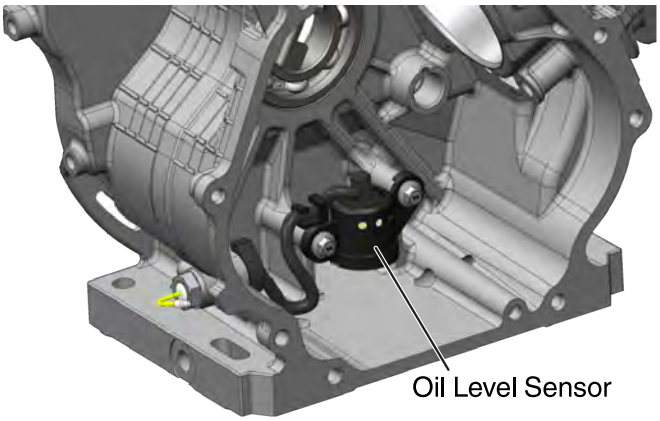


SPN 91, FMI 4: Signal Voltage Low/Open

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Back probe terminal 4 (White/Brown wire) on engine side of the operator panel connector. 3. Connect terminal 4 back probe to red meter test lead on DVOM. 4. Back probe terminal 3 (Brown wire) on engine side of the operator panel connector. 5. Connect terminal 3 back probe to black meter test lead on DVOM. 6. Set DVOM to read volts DC. 7. Turn Ignition ON, Engine OFF. 8. DVOM should read 0.1-4.9 volts DC. 9. Move the throttle control to high speed. Voltage reading should increase. 10. Move the throttle control to low speed. Voltage reading should decrease. 11. When the throttle was moved to low speed was the voltage less than 0.1 VDC?	Go to step 2.	No problem currently exists. Clear codes. While monitoring voltage, try to duplicate failure by performing multiple throttle sweeps.
2	1. Turn Ignition OFF. 2. Remove probe from terminal 4, and back probe terminal 5 (Red/White wire) on engine side of the operator panel connector. 3. Turn Ignition ON, Engine OFF. 4. Does DVOM read greater than 4.9 volts DC?	Voltage is not being returned from the throttle control to the ECM. Look for throttle control problems on the operator panel and/or equipment side.	No problem currently exists. Clear codes. While monitoring voltage, try to duplicate failure by performing multiple throttle sweeps.



SPN 98 Low Oil Level



Circuit Description

The low oil level sensor is mounted within the engine at the base of the crankcase. The low oil level sensor uses run-sense technology to only detect low oil level after the engine is started.

If low oil level triggers SPN 98, engine operation is stopped. The fault is reset when the key switch is turned off and the ECM powers down. Low oil level is monitored at the next engine start cycle.

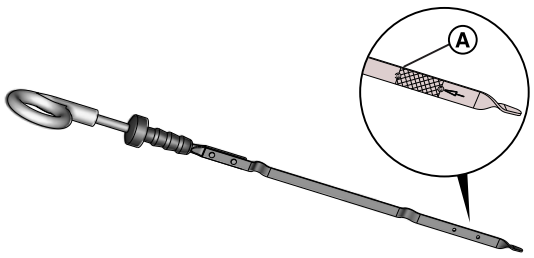
Possible FMIs

The possible FMIs for SPN 98 are as follows:

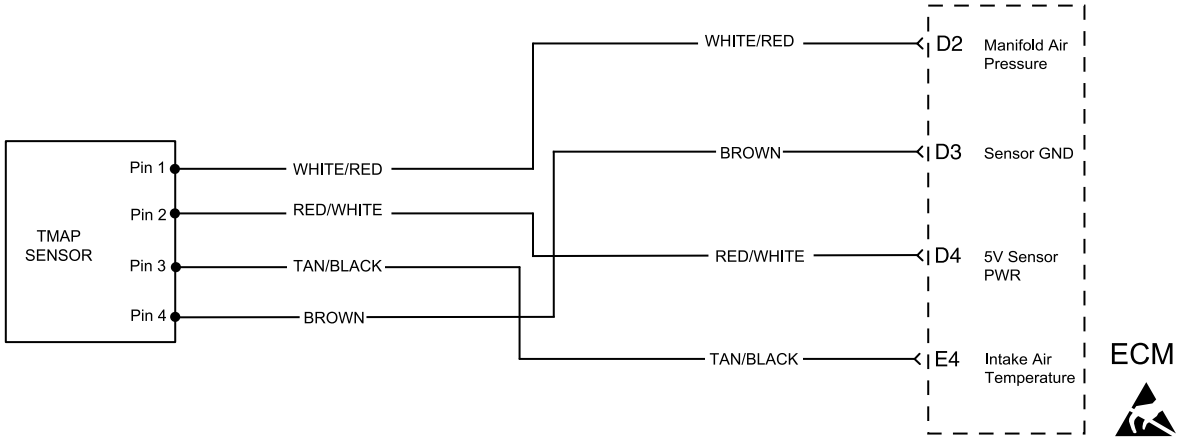
FMI	Description
1	Low oil level error

SPN 98, FMI 1: Low Oil Level Error

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Check engine oil level by verifying that the oil level is within the cross hatch pattern on the dipstick. See **A**, within the image below. 3. Is the engine oil level low?	Fill engine with new oil to the proper level. Start engine to verify repair.	Proceed to step 2.
2	1. Turn Ignition OFF. 2. Disconnect the one-place wire connector between the oil level sensor and the wire harness. 3. Obtain DVOM and set to read ohms. 4. Insert RED meter test lead into V Ω receptacle, and BLACK meter test lead into COM receptacle. 5. Connect red meter test lead to oil level sensor wire at the oil level sensor and the black meter test lead to engine base. 6. Measure resistance. Does the meter read continuity? 7. If the meter reads infinity, check oil sensor wiring for shorts.	Replace oil level sensor	Does meter read infinity? Check sensor wire for shorts.



SPN 102 Manifold Absolute Pressure Sensor (MAP)



Circuit Description

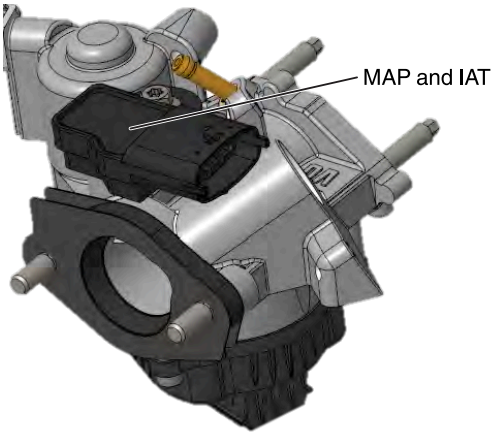
The MAP sensor continuously monitors intake manifold pressure to interpret engine work load to provide accurate fuel and spark delivery for optimal engine performance. The MAP sensor also reads ambient atmospheric pressure at start-up and is stored in the ECM memory. The system will use the stored value with other system sensor data to continue engine operation in the event of a failure. This barometric pressure is also used to judge ambient elevation to provide seamless engine operation at various elevations.

Possible FMIs - SPN 102

The possible FMIs for SPN 102 are as follows:

FMI	Description
3	Signal Voltage High
4	Signal Voltage Low/Open

NOTE: The MAP sensor is part of the TMAP sensor assembly. The sensor assembly is composed of sensing elements for the manifold air pressure (MAP) and intake air temperature (IAT). The TMAP sensor can be replaced independent of the throttle body assembly (ETC). See *SECTION 6 - REMOVAL AND INSTALLATION - Electronic Throttle Control (ETC) - TMAP Sensor Assembly*.



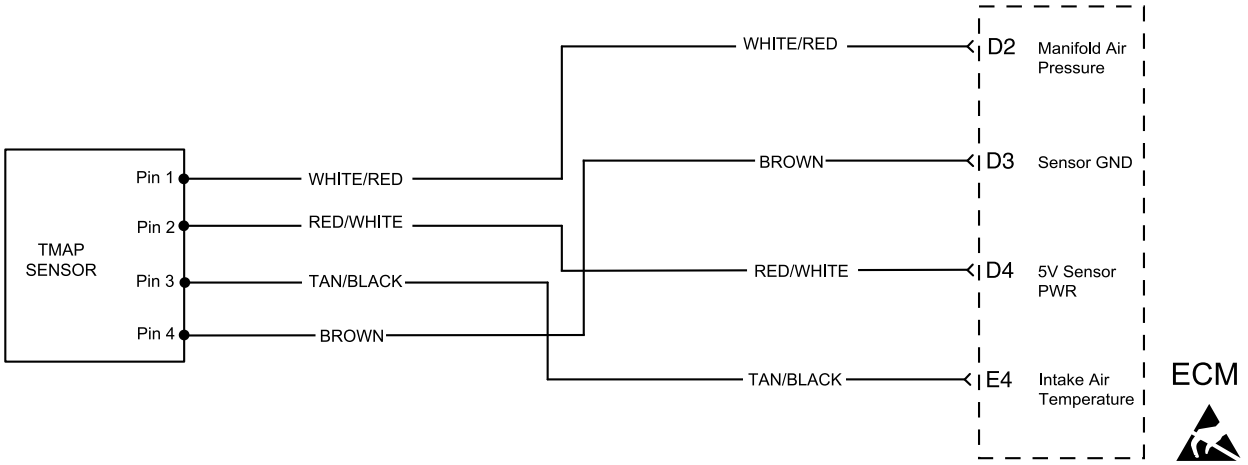
SPN 102, FMI 3: Signal Voltage High

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Back probe terminal D2 (White/Red wire) of ECM connector. 3. Connect terminal D2 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to good ground. 6. Set DVOM to read volts DC. 7. Turn Ignition ON, Engine OFF. 8. Observe voltage on DVOM. 9. Is reading less than 4.6 volts DC?	Problem does not exist	Reading is above 4.6 volts DC. Precede to step 2.
2	If voltage reading is above 4.6 volts DC, check the wire harness for shorts. Is the problem found?	Repair or replace as necessary.	Replace MAP sensor. See *SECTION 6 - REMOVAL AND INSTALLATION- Electronic Throttle Control (ETC) - TMAP Sensor.*

SPN 102, FMI 4: Signal Voltage Low/Open

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Back probe terminal D2 (White/Red wire) of ECM connector. 3. Connect terminal D2 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to good ground. 6. Set DVOM to read volts DC. 7. Turn Ignition ON, Engine OFF. 8. Observe voltage on DVOM. 9. Is reading greater than 0.4 volts DC?	Problem does not exist	Reading is below 0.4 volts DC. Precede to step 2.
2	If voltage reading is below 0.4 volts DC, check the wire harness for shorts. Is the problem found?	Repair or replace as necessary.	Replace MAP sensor. See *SECTION 6 - REMOVAL AND INSTALLATION- Electronic Throttle Control (ETC) - TMAP Sensor.*

SPN 105 Intake Air Temperature Sensor (IAT)



Circuit Description

The IAT sensor is used to monitor incoming air temperature to make dynamic changes to fuel and spark based on ambient temperature conditions. The IAT sensor is a part of the TMAP sensor assembly. The sensing element is located within the throttle body bore.

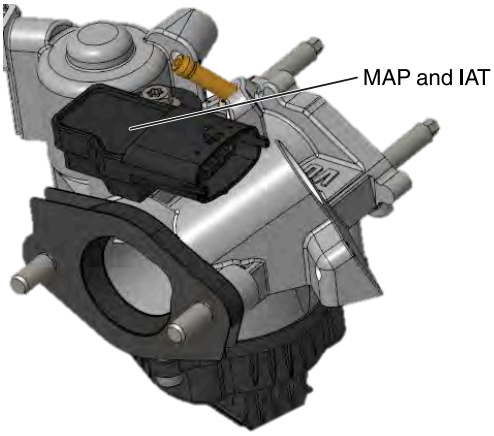
Possible FMIs - SPN 105

The possible FMIs for SPN 105 are as follows:

FMI	Description
2	Intermittent Fail
3	Signal Voltage High/Open
4	Signal Voltage Low

FMI 2: Check to ensure the TMAP connector is fully mated. Check wire harness for breaks, loose connections and shorts.

NOTE: The IAT sensor is part of the TMAP sensor assembly. The sensor assembly is composed of sensing elements for the manifold air pressure (MAP) and intake air temperature (IAT). The TMAP sensor can be replaced independent of the throttle body assembly (ETC). See *SECTION 6 - REMOVAL AND INSTALLATION - Electronic Throttle Control (ETC) - TMAP Sensor Assembly*.



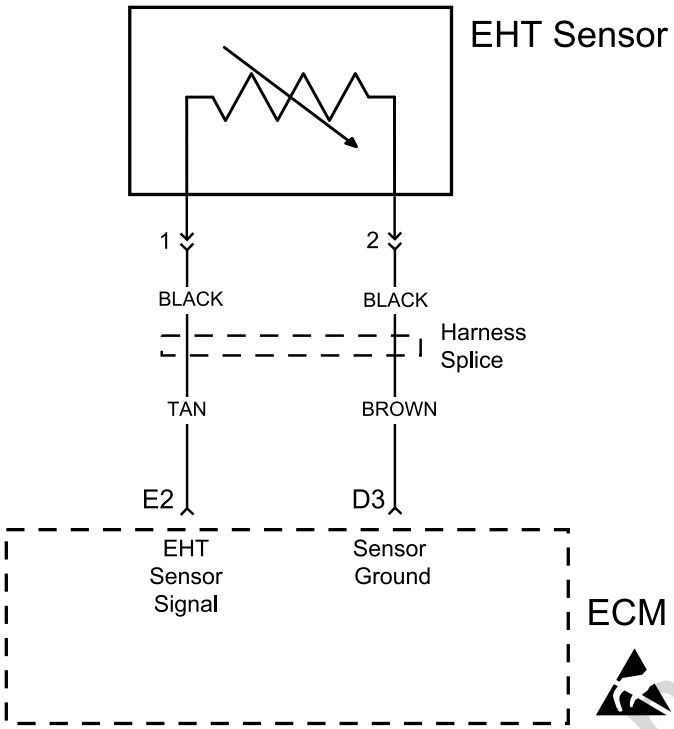
SPN 105, FMI 3: Signal Voltage High/Open

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Back probe terminal E4 (Tan/Black wire) of ECM connector. 3. Connect terminal E4 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to good ground. 6. Set DVOM to read volts DC. 7. Turn Ignition ON, Engine OFF. 8. Observe voltage on DVOM. 9. Is reading less than 4.85 volts DC?	Problem does not exist	Reading is above 4.6 volts DC. Precede to step 2.
2	If voltage reading is above 4.85 volts DC, check the wire harness for shorts. Is the problem found?	Repair or replace as necessary.	Replace MAP sensor. See *SECTION 6 - REMOVAL AND INSTALLATION- Electronic Throttle Control (ETC) - TMAP Sensor.*

SPN 105, FMI 4: Signal Voltage Low

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Back probe terminal E4 (Tan/Black wire) of ECM connector. 3. Connect terminal E4 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to good ground. 6. Set DVOM to read volts DC. 7. Turn Ignition ON, Engine OFF. 8. Observe voltage on DVOM. 9. Is reading greater than 0.15 volts DC?	Problem does not exist	Reading is below 0.15 volts DC. Precede to step 2.
2	If voltage reading is below 0.15 volts DC, check the wire harness for shorts. Is the problem found?	Repair or replace as necessary.	Replace MAP sensor. See *SECTION 6 - REMOVAL AND INSTALLATION- Electronic Throttle Control (ETC) - TMAP Sensor.*

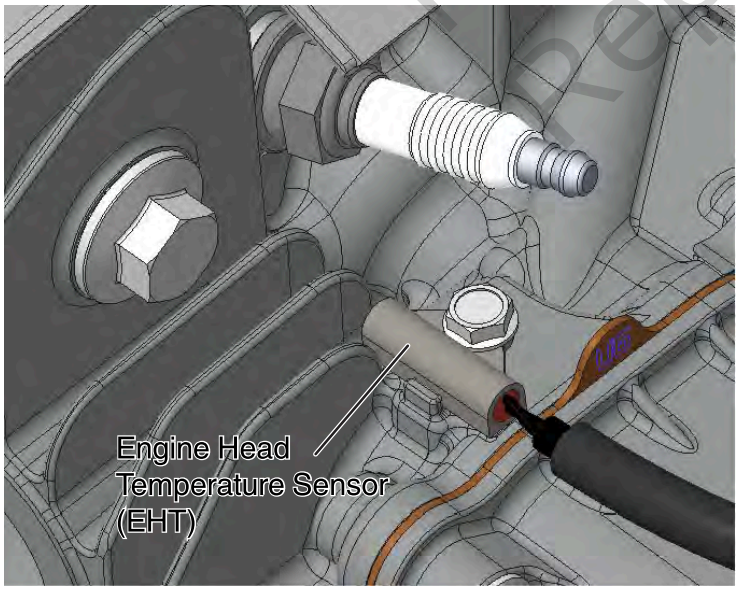
SPN 110 Engine Head Temperature Sensor (EHT)



Circuit Description

The EHT sensor uses a thermistor to control signal voltage to the ECM. The ECM applies 5 volts on the sensor circuit. Sensor resistance changes as ambient temperature changes, which in turn affects the voltage return to the ECM.

NOTE: The EHT sensor is located on the cylinder head, adjacent to the spark plug. See image below for sensor location.



Possible FMIs - SPN 110

The possible FMIs for SPN 110 are as follows:

FMI	Description
2	Intermittent Fail
3	Signal Voltage High/Open
4	Signal Voltage Low

FMI 2: ECM sees that signal voltage has been intermittent. Problem may be wiring harness and/or connections, or EHT sensor damage.

FMI 4: ECM continuously monitors voltage input on ECM terminal E2. If voltage falls below the preset threshold for longer than one second, FMI 4 will set.

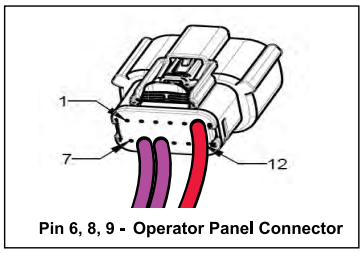
SPN 110, FMI 3: Voltage High/Open

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Back probe terminal E2 (Tan wire) of ECM connector. 3. Connect terminal E2 back probe to red meter test lead on DVOM. 4. Back probe terminal D3 (Brown wire) of ECM connector. 5. Connect terminal D3 back probe to black meter test lead on DVOM. 6. Set DVOM to read volts DC. 7. Turn Ignition ON, Engine OFF. 8. Observe voltage on DVOM. 9. Is reading 0.5-4.5 volts DC?	EHT sensor OK.	Reading is above 4.5 volts DC. EHT sensor is bad. Replace EFI wire harness. **NOTE:** EHT sensor is an integral part of the EFI wire harness and is not sold separately.

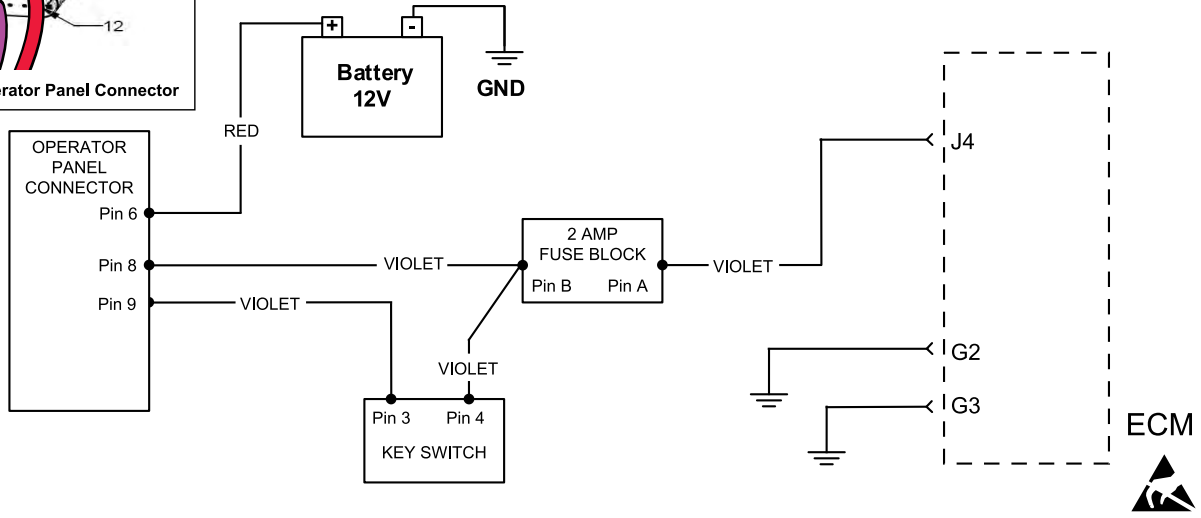
SPN 110, FMI 4: Voltage Low

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Back probe terminal E2 (Tan wire) of ECM connector. 3. Connect terminal E2 back probe to red meter test lead on DVOM. 4. Back probe terminal D3 (Brown wire) of ECM connector. 5. Connect terminal D3 back probe to black meter test lead on DVOM. 6. Set DVOM to read volts DC. 7. Turn Ignition ON, Engine OFF. 8. Observe voltage on DVOM. 9. Is reading 0.5-4.5 volts DC?	EHT sensor OK.	Go to step 2.
2	1. Reading is below 0.5 volts DC. 2. Is ECM connector fully mated?	EHT sensor is bad. Replace EFI wire harness. **NOTE:** EHT sensor is an integral part of the EFI wire harness and is not sold separately.	Connect connector.

SPN 158 Ignition Key Voltage



Pin 6, 8, 9 - Operator Panel Connector



Circuit Description

The EFI system operates with a battery voltage of 9-16 volts. During normal operation, the MIL is illuminated if the voltage is above 16 volts (setting FMI 3) or below 9 volts (setting FMI 4) for a specified amount of time.

To determine the system voltage to the ECM, take a voltage measurement at terminal J4. If the voltage is not within 0.01 volt of the measurement obtained at the battery (12-14.5 volts DC) measuring between the positive (+) and negative (-) posts with a DVOM, determine the fault associated with the ignition circuit or charging circuit.

Possible FMIs - SPN 158

The possible FMIs for SPN 158 are as follows:

FMI	Description
3	Voltage High
4	Voltage Low

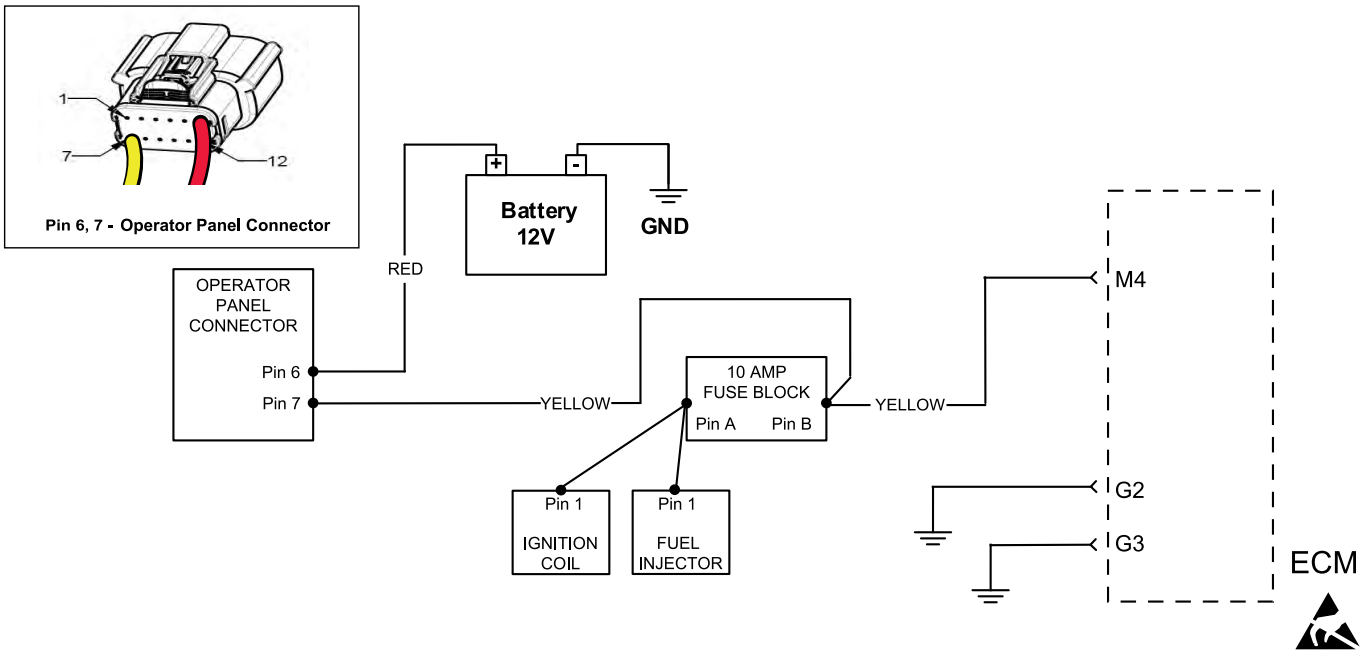
SPN 158, FMI 3: Voltage High

Step	Action	Yes	No
1	1. Connect red meter test lead on DVOM to battery positive (+) post. 2. Connect black meter test lead on DVOM to battery negative (-) post. 3. Set DVOM to read volts DC. 4. Start and run engine at full speed (3600 RPM). 5. Observe voltage on DVOM. 6. Is reading 12.2-14.5 volts DC?	System voltage OK.	Reading is above 16 volts. Check charging system. See Repair Manual.

SPN 158, FMI 4: Voltage Low

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Set DVOM to read volts DC. 3. Connect red meter test lead on DVOM to battery positive (+) post. 4. Connect black meter test lead on DVOM to ground. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read 12+ volts DC?	Go to step 2.	Charge or replace battery.
2	1. Turn Ignition OFF. 2. Back probe terminal 8 (Violet wire) at the operator panel connector. 3. Connect terminal 8 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to ground. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read 12+ volts DC?	Go to step 3.	Check vehicle or equipment side for problems.
3	1. Check condition of 2 amp fuse in the fuse block. Is fuse OK?	Go to step 4.	Replace fuse and retest.
4	1. Turn Ignition OFF. 2. Back probe terminal J4 (Violet wire) at ECM connector. 3. Connect terminal J4 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to ground. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read 12+ volts DC?	No problem currently exists.	Inspect EFI wire harness between the operator panel connector and terminal J4 (Violet wire) at ECM connector.

SPN 168 Battery Voltage



Circuit Description

The EFI system operates with a battery voltage of 9-16 volts. During normal operation, the MIL is illuminated if the voltage is above 16 volts (setting FMI 3) or below 9 volts (setting FMI 4) for a specified amount of time.

To determine the system voltage to the ECM, take a voltage measurement at terminal M4. If the voltage is not within 0.01 volt of the measurement obtained at the battery (12-14.5 volts DC) measuring between the positive (+) and negative (-) posts with a DVOM, determine the fault associated with the ignition circuit or charging circuit.

Possible FMIs - SPN 168

The possible FMIs for SPN 168 are as follows:

FMI	Description
3	Voltage High
4	Voltage Low

SPN 168, FMI 3: Voltage High

Step	Action	Yes	No
1	1. Connect red meter test lead on DVOM to battery positive (+) post. 2. Connect black meter test lead on DVOM to battery negative (-) post. 3. Set DVOM to read volts DC. 4. Start and run engine at full speed (3600 RPM). 5. Observe voltage on DVOM. 6. Is reading 12.2-14.5 volts DC?	System voltage OK.	Reading is above 16 volts. Check charging system.

SPN 168, FMI 4: Voltage Low

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Set DVOM to read volts DC. 3. Connect red meter test lead on DVOM to battery positive (+) post. 4. Connect black meter test lead on DVOM to ground. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read 12+ volts DC?	Go to step 2.	Charge or replace battery.
2	1. Turn Ignition OFF. 2. Back probe terminal 6 (Red wire) at the operator panel connector. 3. Connect terminal 6 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to ground. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read 12+ volts DC?	Go to step 3.	Check vehicle or equipment side for problems.
3	1. Check condition of 10 amp fuse in the fuse panel. Is fuse OK?	Go to step 4.	Replace fuse and retest.
4	1. Turn Ignition OFF. 2. Back probe terminal M4 (Yellow wire) at ECM connector. 3. Connect terminal M4 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to ground. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read 12+ volts DC?	No problem currently exists.	Inspect EFI wire harness between the main vehicle connector and terminal M4 (Yellow wire) at ECM connector.

SPN 190 Engine Overspeed Detection

Circuit Description

The ECM monitors engine speed for overspeed detection. If an engine overspeed event is detected, and actively engaging the rev limiter, a fault will be triggered and the MIL will flash. If an engine overspeed event occurs, but is not actively engaging the rev limiter, the fault will be stored in the ECM memory.

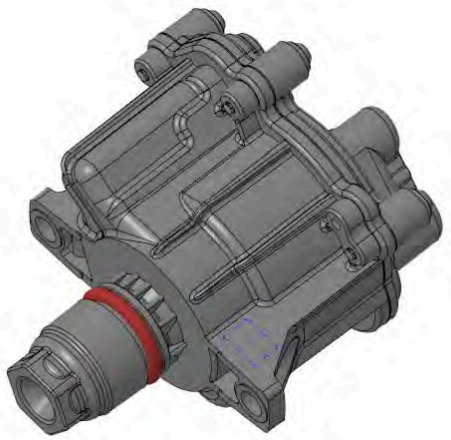
Possible FMIs - SPN 190

The possible FMIs for SPN 190 are as follows:

FMI	Description
15	Over Speed Detected

FMI 15: Verify that top no load engine speed is operating at the intended speed. If active engine overspeeding problem continues, check intake system for leaks, repair or replace as necessary.

SPN 633 Vapor Detection in FDI



Circuit Description

The ECM monitors the fuel injector pulse width (the amount of time the fuel injector is energized or open) to detect vapor in the injector. Fuel vapor in the injector can be detected during the engine's cranking state and running state.

The use of high Reid Vapor Pressure (RVP) fuel in high temperature environments can lead to vapors within the system. Example: Winter formulated fuel used in summer conditions.

Possible FMIs - SPN 633

The possible FMIs for SPN 633 are as follows:

FMI	Description
8	Vapors detected in FDI during RUN state
11	Vapors detected in FDI during CRANKING state

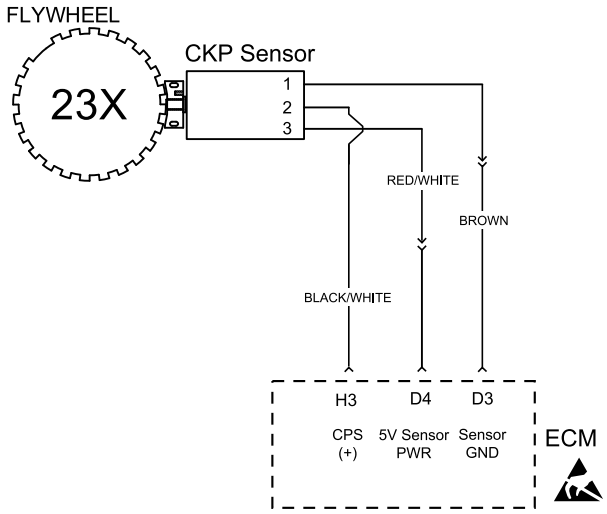
SPN 633, FMI 8: Vapors Detected in FDI During RUN State

Step	Action	Yes	No
1	Is high RVP (winter blend) fuel being used in a high ambient temperature environment?	Drain fuel and replace with new.	Proceed to Step 2.
2	Are the air cooling passages blocked or dirty?	Clean all engine cooling system components. This includes: blower housing, fan, cylinder air guides, cylinder cooling ribs.	Proceed to Step 3.
3	Is the engine being run in a high ambient temperature environment?	Move engine to cooler surroundings.	-

SPN 633, FMI 11: Vapors Detected in FDI During CRANKING State

Step	Action	Yes	No
1	Is high RVP (winter blend) fuel being used in a high ambient temperature environment?	Drain fuel and replace with new.	Proceed to Step 2.
2	Is the engine being asked to start in a high ambient temperature environment?	Move engine to cooler surroundings.	Proceed to Step 3.
3	Was the engine previously running and is now being asked to restart hot?	Allow the engine to cool prior to restarting.	-

SPN 636 Crankshaft Wrong Tooth Number



Circuit Description

The CKP sensor works in conjunction with the 23X reluctor target wheel on the flywheel. Each tooth on the reluctor wheel is equally spaced with 1 tooth missing for the reference sync pulse. As the crankshaft rotates, the reluctor target wheel interrupts a magnetic field produced by an internal sensor magnet. The CKP sensor is a Hall Effect sensor and produces an ON/OFF DC voltage pulse when it detects the magnetic field. The frequency of the CKP sensor output signal is dependent upon crankshaft speed. The ECM uses each CKP sensor output signal to determine crankshaft speed and identify crankshaft position.

With the spark under control of the ECM, the engine will not run if the CKP sensor signal is lost. The ECM will not be able to determine which stroke the pistons are on.

Possible FMIs - SPN 636

The possible FMIs for SPN 636 are as follows:

FMI	Description
2	Additional Edges Detected
8	Missing or Additional Tooth Detected

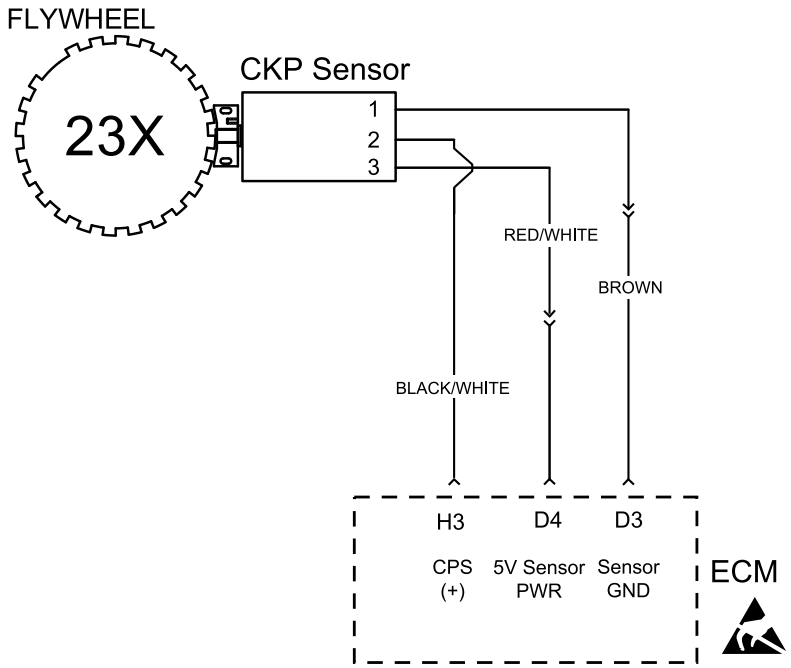
FMI 2: Erratic signal possibly caused by excessive air gap or electronic noise.

FMI 8: Abnormal frequency due to excessive air gap or metallic debris on sensor.

SPN 636, FMI 2: Not Enough Teeth Detected

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Check CKP sensor air gap. 3. Is CKP sensor air gap set at 0.010-0.015 inches (0.25-0.38 mm)? **NOTE:** If air gap is too large, engine speed detection may be delayed at slow speed. The engine may exhibit poor starting performance.	Go to step 2.	Adjust as necessary.
2	1. Obtain a Briggs & Stratton Spark Tester (Part No. 84003327). 2. Install spark tester in line with ignition coil and spark plug. 3. Look for spark in tester windows while cranking engine. 4. Is spark observed?	Go to step 3.	Repair or replace spark plug and/or ignition coil.
3	1. Turn Ignition OFF. 2. Check valve lash adjustment. 3. Is valve lash within specification?	Go to step 4.	Adjust as necessary.
4	1. Replace CKP sensor. 2. Is problem corrected?	-	Repair or replace EFI wire harness.

SPN 637 Missing Crank Sensor (CKP)



Circuit Description

The CKP sensor works in conjunction with the 23X reluctor target wheel on the flywheel. Each tooth on the reluctor wheel is equally spaced with 1 tooth missing for the reference sync pulse. As the crankshaft rotates, the reluctor target wheel interrupts a magnetic field produced by an internal sensor magnet. The CKP sensor is a Hall Effect sensor and produces an ON/OFF DC voltage pulse when it detects the magnetic field. The frequency of the CKP sensor output signal is dependent upon crankshaft speed. The ECM uses each CKP sensor output signal to determine crankshaft speed and identify crankshaft position.

With the spark under control of the ECM, the engine will not run if the CKP sensor signal is lost. The ECM will not be able to determine which stroke the pistons are on.

Possible FMIs - SPN 637

The possible FMIs for SPN 637 are as follows:

FMI	Description
7	Missing Crankshaft Sensor Signal

SPN 637, FMI 7: Missing Crank Sensor Signal

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Disconnect and connect CKP sensor connector. 3. Attempt to start engine. Does engine start?	Problem corrected.	Go to step 2.
2	1. Turn Ignition OFF. 2. Check CKP sensor air gap. 3. Is CKP sensor air gap set at 0.010-0.150 inches (0.25-0.38 mm)? **NOTE:** If air gap is too large, engine speed detection may be delayed at slow speed. The engine may exhibit poor starting performance.	Go to step 3.	Adjust as necessary. Go to step 3 if engine still does not start.
3	1. Turn Ignition OFF. 2. Replace CKP sensor and set air gap at 0.010-0.150 inches (0.25-0.38 mm). 3. Is problem corrected?	-	Check for damaged or broken wiring. Repair or replace EFI wire harness.

SPN 639 CAN BUS Offline

Circuit Description

The ECM monitors the CAN bus for communication between devices. If expected CAN bus communication is lost, SPN 639 will be stored in the ECM.

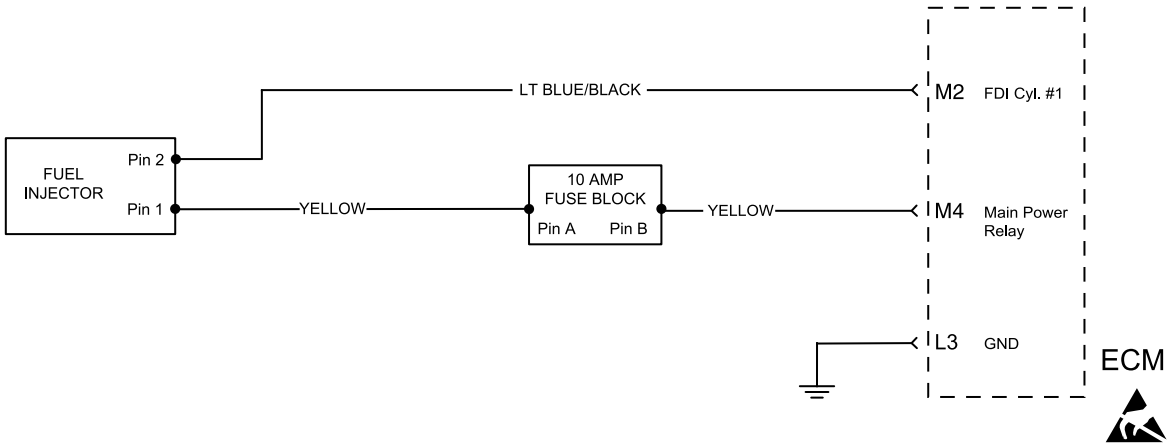
Possible FMIs - SPN 639

The possible FMIs for SPN 639 are as follows:

FMI	Description
19	Data Error

For diagnosing potential CAN BUS system problems, see *CAN BUS Troubleshooting - Check Voltages, Check Waveforms* in this section.

SPN 651 Fuel Injector



Circuit Description

The ECM controls the fuel injector by pulse width modulating the voltage to the injector. If the ECM detects the fuel injector voltage signal is not within the expected range, a fuel injector control DTC is set.

Although the DTC indicates the fuel injector is faulty, the technician must determine if the fault is in the control circuit from the ECM or the +12v circuit from the main power relay.

NOTE: Injector resistance between pins 1 and 2 should be 1.8-2.5 ohms at room temperature.

NOTE: If an ignition coil fault code is active, the fuel injector is turned off.

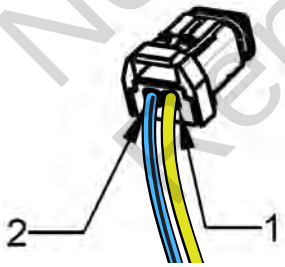
Possible FMIs - SPN 651

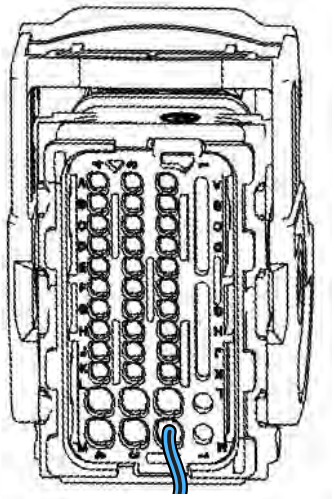
The possible FMIs for SPN 651 are as follows:

FMI	Description
3	Signal Voltage High
4	Signal Voltage Low/Open

SPN 651, FMI 3: Voltage High/Open

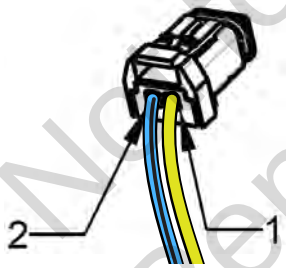
Step	Action	Yes	No
1	1. Perform the Injector Cylinder 1 Firing Test. See *TEST PROCEDURES* in this section. 2. Did the test Pass?	Problem does not currently exist.	Go to step 2.
2	1. Turn Ignition OFF. 2. Disconnect fuel injector connector. 3. Install Briggs & Stratton Noid Light (Part No. 19623). 4. Crank the engine. 5. Does Noid Light flash?	Replace fuel injector.	Go to step 3.
3	1. Turn Ignition OFF. 2. Remove Noid Light and connect fuel injector connector. 3. Back probe (using fused patch cord) terminal 1 (Yellow wire) of fuel injector connector. 4. Connect terminal 1 back probe to red meter test lead on DVOM. 5. Connect black meter test lead to a known good ground. 6. Set DVOM to read volts DC. 7. Turn Ignition ON, Engine OFF. 8. Does DVOM read 12.2-13.5 volts DC?	Go to step 4.	Reading is below 12.2 volts DC. Perform visual and continuity check of 10 amp Battery fuse (Red).
4	1. Turn Ignition OFF. 2. Disconnect fuel injector electrical connector. 3. Disconnect ECM connector. 4. Back probe terminal 2 (Lt. Blue/Black wire) of fuel injector connector. 5. Connect terminal 2 back probe to red meter test lead on DVOM. 6. Back probe terminal M2 (Lt. Blue/Black wire) of ECM connector. 7. Connect terminal M2 back probe to black meter test lead on DVOM. 8. Set DVOM to read resistance. 9. Does DVOM read less than 0.5 ohms?	Control circuit is OK.	Reading is above 0.5 ohms. Check terminals for corrosion or replace EFI wire harness. **NOTE:** IF DTC still present after replacement of EFI wire harness, then replace ECM due to failed injector driver.

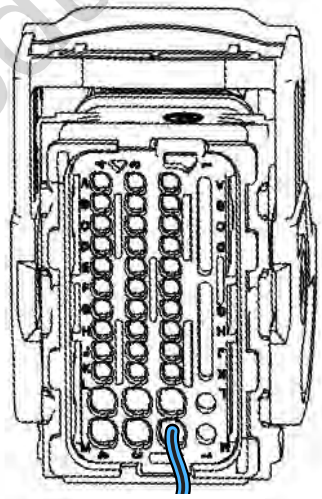




SPN 651, FMI 4: Voltage Low

Step	Action	Yes	No
1	1. Perform the Injector 1 Firing Test. See *TEST PROCEDURES* in this section. 2. Did the test Pass?	Problem does not currently exist.	Go to step 2.
2	1. Turn Ignition OFF. 2. Back probe terminal M2 (Lt. Blue/Black wire) of ECM connector. 3. Connect terminal M2 back probe to red meter test lead on DVOM. 4. Connect black meter test lead to a known good ground. 5. Set DVOM to read volts DC. 6. Turn Ignition ON, Engine OFF. 7. Does DVOM read 12.2-13.5 volts DC?	No problem.	Go to step 3.
3	1. Turn Ignition OFF. 2. Back probe (using fused patch cord) terminal 1 (Yellow wire) of fuel injector connector. 3. Connect terminal 1 back probe to black meter test lead on DVOM. 4. Set DVOM to read resistance. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read open line O/L (no continuity)?	Go to step 4.	Repair or replace wire between ECM and fuel injector, or replace EFI wire harness.
4	1. Turn Ignition OFF. 2. Remove back probe from terminal M2 of ECM connector. 3. Back probe terminal 2 (Lt. Blue/Black wire) of fuel injector connector. 4. Connect terminal 2 back probe to red meter test lead on DVOM. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read open line O/L (no continuity)?	Injector OK.	Replace Injector





SPN 818 Voltage Protection

Circuit Description

The ECM uses a 5 volt reference system for various sensor reference voltages. The ECM also monitors the voltage level of the 5 volt system, and detects three possible failure modes: shorted high above 5V (FMI 3), shorted low (FMI 4), and if the temperature of the 5V regulator is over temperature.

If the system has been shorted high, with excessively high voltage such as with 12V battery voltage, permanent damage to the ECM may occur.

If the system has been shorted low (FMI 4), the system current is limited, so damage will not occur in this event. However, the system temperature may increase causing FMI 16 to set.

Possible FMIs - SPN 818

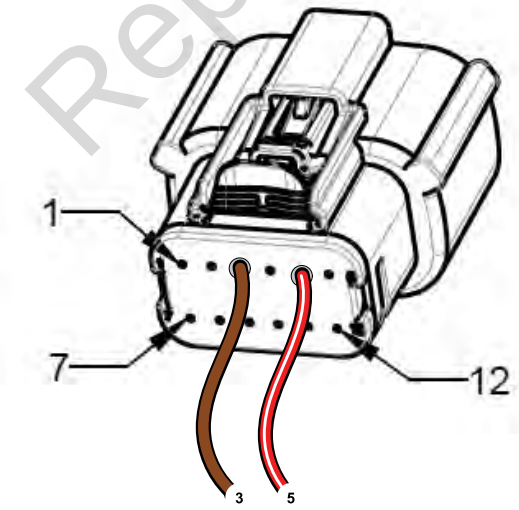
The possible FMIs for SPN 818 are as follows:

FMI	Description
3	5V Supply High
4	5V Supply Low or Shorted to Ground
16	Over Temperature

FMI 16: Over temperature of the 5 volt voltage regulator.

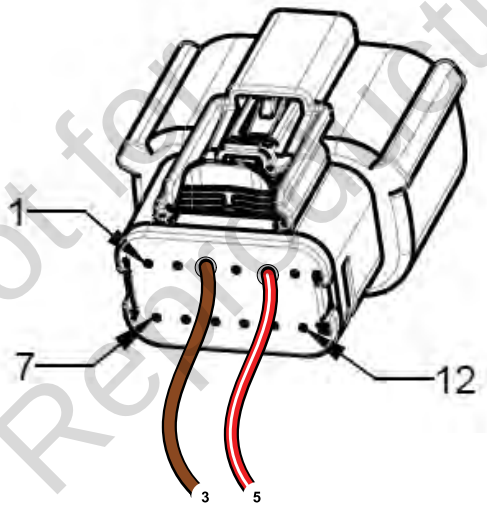
SPN 818, FMI 3: Short 5V Supply High

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Back probe terminal 5 (Red/White wire) at the main operator panel connector. 3. Connect terminal 5 back probe to red meter test lead on DVOM. 4. Back probe terminal 3 (Brown wire) at the main vehicle connector. 5. Connect terminal 3 back probe to black meter test lead on DVOM. 6. Set DVOM to read volts DC. 7. Turn Ignition ON, Engine OFF. 8. Does DVOM read greater than 5 volts DC?	Replace EFI wire harness, or locate and repair 5 volt wire shorted to battery voltage. Disconnect connector from operator panel to see if any change occurs. Check ECM for damage.	No current issue.



SPN 818, FMI 4: Short 5V Supply Low

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Back probe terminal 5 (Red/White wire) at the operator panel connector. 3. Connect terminal 5 back probe to red meter test lead on DVOM. 4. Back probe terminal 3 (Brown wire) at the operator panel connector. 5. Connect terminal 3 back probe to black meter test lead on DVOM. 6. Set DVOM to read volts DC. 7. Turn Ignition ON, Engine OFF. 8. Does DVOM read 5 volts DC?	No current issue.	Go to step 2.
2	1. Turn Ignition OFF. 2. Disconnect ECM connector. 3. Set DVOM to read resistance. 4. Remove back probe from terminal 3. Connect black meter test lead on DVOM to battery negative terminal. 5. Is resistance found (and **not** O/L)?	Replace EFI wire harness, or locate and repair short to ground.	Replace ECM.



SPN 1110 Engine Over Temperature For Maximum Allowed Time

Circuit Description

The ECM monitors the EHT for high engine temperature.

SPN 1110, SPN 1569, and SPN 6805 are for engine temperature monitoring faults.

If the ECM notes that the cylinder head temperature is higher than the overheat temperature threshold, SPN 1569 and SPN 6805 (Engine Over Temperature While Running) will be triggered and the engine will limit the maximum throttle and maximum engine speed.

If the engine overheat condition continues while the engine is running, SPN 1110 will be triggered and the engine will shut down allowing it to cool.

The engine temperature monitoring function needs to be thought of as a two-step system:

1. Engine begins to overheat, SPN 1569 and SPN 6805 are triggered and engine torque is reduced by limiting the throttle and engine speed.
2. Engine continues to operate while monitoring the engine temperature. If the engine temperature is not reduced below the overheat threshold limit, SPN 1110 is triggered and the engine shuts down to protect from damage.

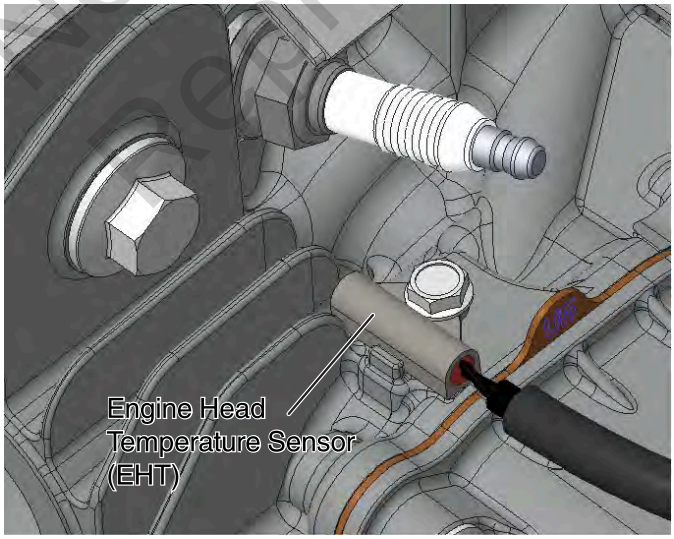
Possible FMIs - SPN 1110

The possible FMIs for SPN 1110 are as follows:

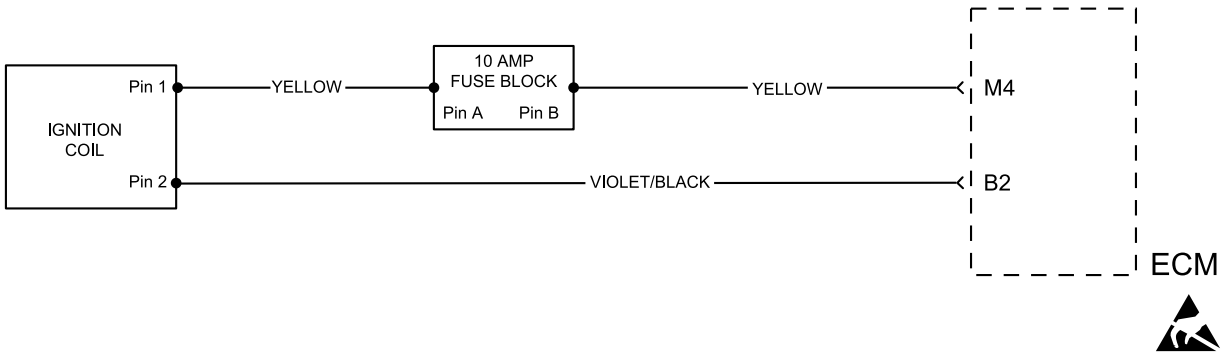
FMI	Description
0	Cylinder head over temperature

SPN 1110, FMI 0: Head Over Temperature

Step	Action	Yes	No
1	Visually inspect the engine. Is the problem found?	Repair.	Proceed to step 2.
2	Check engine oil and oil level. Is oil level low?	Fill to proper level. See the engine operator manual.	Proceed to step 3.
3	Check ALL engine cooling system components. This includes: blower housing, fan, engine air guides, cylinder head air guides, cylinder head cooling fins, engine cooling fins. Is the problem found?	Clean engine cooling system components	Proceed to step 4.
4	Inspect internal engine components for damage. Is the problem found?	See your engine's repair manual for proper teardown and inspection procedures.	-



SPN 1268 Cylinder 1 Ignition Coil



Circuit Description

The ignition coil has an ignition (B+ voltage) and a ground circuit. The ECM controls the ignition coil by completing the ground circuit as needed.

When an ignition coil fault is set the ECM also shuts down the fuel injector.

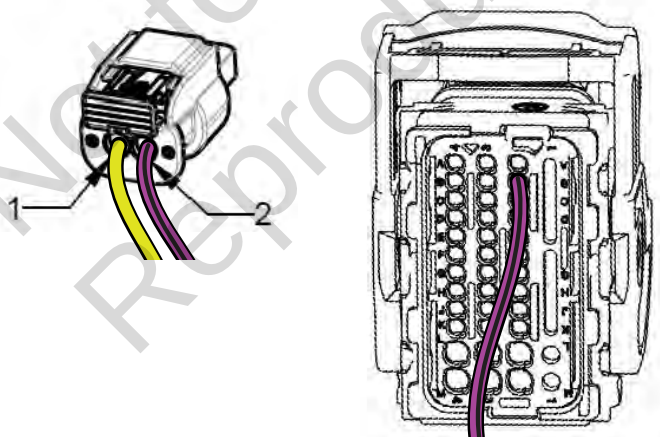
Possible FMIs - SPN 1268

The possible FMIs for SPN 1268 are as follows:

FMI	Description
3	Signal Voltage High
4	Signal Voltage Low/Open

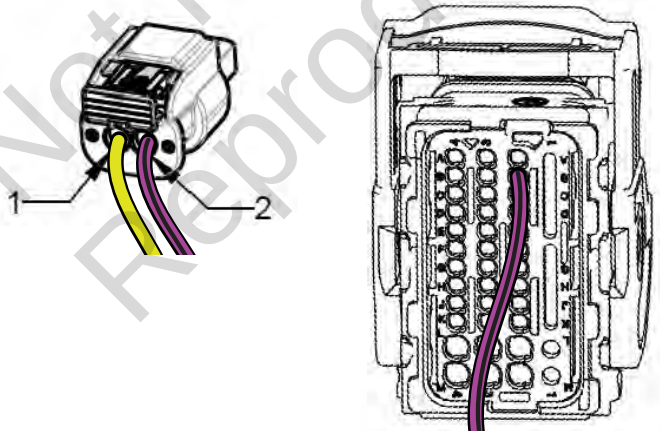
SPN 1268, FMI 3: Short to High/Open

Step	Action	Yes	No
1	1. Perform the Ignition Coil Spark Test. See *TEST PROCEDURES* in this section. 2. Did the test Pass?	Problem does not currently exist.	Go to step 2.
2	1. Turn Ignition OFF. 2. Obtain a Briggs & Stratton Spark Tester (Part No. 19368). 3. Install spark tester in line with ignition coil and spark plugs. 4. Look for spark in tester windows while cranking engine. 5. Is spark observed?	No current problem.	Go to step 3.
3	1. Turn Ignition OFF. 2. Back probe (using fused patch cord) terminal 1 (Yellow wire) of ignition coil connector. 3. Connect terminal 1 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to a known good ground. 5. Set DVOM to read volts DC. 6. Turn Ignition ON, Engine OFF. 7. Does DVOM read 12.2-13.5 volts DC?	Go to step 4.	Reading is below 12.2 volts DC. Perform visual and continuity check of 10 amp Battery fuse (Red).
4	1. Turn Ignition OFF. 2. Remove probe from terminal 1, and back probe terminal 2 (Violet/Black wire) of ignition coil connector. 3. Disconnect ECM connector. 4. Back probe terminal B2 (Violet/Black wire) of ECM connector. 5. Connect terminal B2 back probe to black meter test lead on DVOM. 6. Set DVOM to read resistance. 7. Does DVOM read between 0.43-0.65 ohms?	Check wire harness. Repair or replace wire harness.	Replace ignition coil. Resistance reading is above 0.65 ohms. Repair or replace wire harness.



SPN 1268, FMI 4: Short Low

Step	Action	Yes	No
1	1. Perform the Ignition Coil Spark Test. See *TEST PROCEDURES* in this section. 2. Did the test Pass?	Problem does not currently exist.	Go to step 2.
2	1. Turn Ignition OFF. 2. Back probe terminal B2 (Violet/Black wire) of ECM connector. 3. Connect terminal B2 back probe to red meter test lead on DVOM. 4. Connect black meter test lead to a known good ground. 5. Set DVOM to read volts DC. 6. Turn Ignition ON, Engine OFF. 7. Does DVOM read 12.2-13.5 volts DC?	No problem.	Go to step 3.
3	1. Turn Ignition OFF. 2. Back probe (using fused patch cord) terminal 1 (Yellow wire) of ignition coil connector. 3. Connect terminal 1 back probe to black meter test lead on DVOM. 4. Set DVOM to read resistance. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read open line O/L (no continuity)?	Go to step 4.	Repair or replace wire between ECM and ignition coil, or replace EFI wire harness.
4	1. Turn Ignition OFF. 2. Remove back probe from terminal B2 of ECM connector. 3. Back probe terminal 2 (Violet/Black wire) of ignition coil connector. 4. Connect terminal 2 back probe to red meter test lead on DVOM. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read open line O/L (no continuity)?	Ignition coil OK.	Replace ignition coil.



SPN 1569 Engine Over Temperature While Running

Circuit Description

The ECM monitors the EHT for high engine temperature.

SPN 1110, SPN 1569, and SPN 6805 are for engine temperature monitoring faults.

If the ECM notes that the cylinder head temperature is higher than the overheat temperature threshold, SPN 1569 and SPN 6805 (Engine Over Temperature While Running) will be triggered and the engine will limit the maximum throttle and maximum engine speed.

If the engine overheat condition continues while the engine is running, SPN 1110 will be triggered and the engine will shut down allowing it to cool.

The engine temperature monitoring function needs to be thought of as a two-step system:

1. Engine begins to overheat, SPN 1569 and SPN 6805 are triggered and engine torque is reduced by limiting the throttle and engine speed.
2. Engine continues to operate while monitoring the engine temperature. If the engine temperature is not reduced below the overheat threshold limit, SPN 1110 is triggered and the engine shuts down to protect from damage.

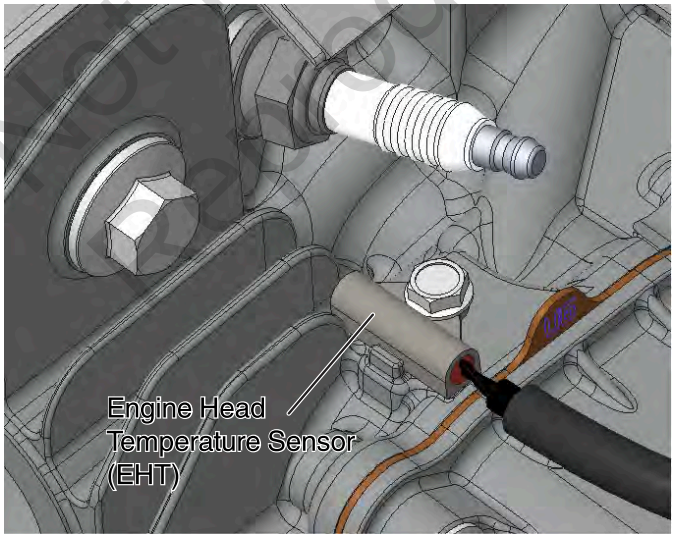
Possible FMIs - SPN 1569

The possible FMIs for SPN 1569 are as follows:

FMI	Description
16	Cylinder head over temperature

SPN 1569, FMI 16: Head Over Temperature

Step	Action	Yes	No
1	Visually inspect the engine. Is the problem found?	Repair.	Proceed to step 2.
2	Check engine oil and oil level. Is oil level low?	Fill to proper level. See the engine operator manual.	Proceed to step 3.
3	Check ALL engine cooling system components. This includes: blower housing, fan, engine air guides, cylinder head air guides, cylinder head cooling fins, engine cooling fins. Is the problem found?	Clean engine cooling system components	Proceed to step 4.
4	Inspect internal engine components for damage. Is the problem found?	See your engine's repair manual for proper teardown and inspection procedures.	-



SPN 5419 Electronic Throttle Control (ETC)

Circuit Description

The ETC controls engine speed with a DC motor built into the throttle body. The DC motor movement is very precise and computer controlled from the feedback from the TPS and target engine speed. The ECM maintains engine speed and adjusts throttle plate angle instantaneously to maintain target engine speed.

NOTE: When the ignition is ON, the ETC motor is not powered and the throttle remains in a rest position within the throttle assembly. This is normal operation. The ETC DC motor is powered up during engine start.

Mechanical

Look for excessive carbon buildup between the throttle plate and throttle body bore, or debris inhibiting movement of the throttle plate.

Are either of these conditions found?

Yes- Clean and retest.

No- If active SPN 5419 fault persists after cleaning, replace throttle body assembly. See *SECTION 6 - REMOVAL AND INSTALLATION - Electronic Throttle Control (ETC)*.

Possible FMIs - SPN 5419

The possible FMIs for SPN 5419 are as follows:

FMI	Description
3	ETC Driver Pin 1 and/or Pin 2 Shorted High
4	ETC Driver Pin 1 and/or Pin 2 Shorted Low
5	ETC Driver Circuit Open
6	ETC Driver Shorted Between Pins 1 and 2
8	Pulse Width Modulation Out of Range
15	ETC Driver Over Temperature **WARNING**
16	Driver Over Temperature

NOTE: The ETC consists of the TPS, ECM, MAP sensor, MAT sensor, throttle body, and stepper motor. The ETC is not serviceable and can not be physically tested. If any SPN 5419 FMI is present, see *TEST PROCEDURES* in this section for information on performing the Electronic Throttle Sweep Test. Replace ETC if test fails.

SPN 6805 Diagnostic

Circuit Description

The ECM monitors the EHT for high engine temperature.

SPN 1110, SPN 1569, and SPN 6805 are for engine temperature monitoring faults.

If the ECM notes that the cylinder head temperature is higher than the overheat temperature threshold, SPN 1569 and SPN 6805 (Engine Over Temperature While Running) will be triggered and the engine will limit the maximum throttle and maximum engine speed.

If the engine overheat condition continues while the engine is running, SPN 1110 will be triggered and the engine will shut down allowing it to cool.

The engine temperature monitoring function needs to be thought of as a two-step system:

1. Engine begins to overheat, SPN 1569 and SPN 6805 are triggered and engine torque is reduced by limiting the throttle and engine speed.
2. Engine continues to operate while monitoring the engine temperature. If the engine temperature is not reduced below the overheat threshold limit, SPN 1110 is triggered and the engine shuts down to protect from damage.

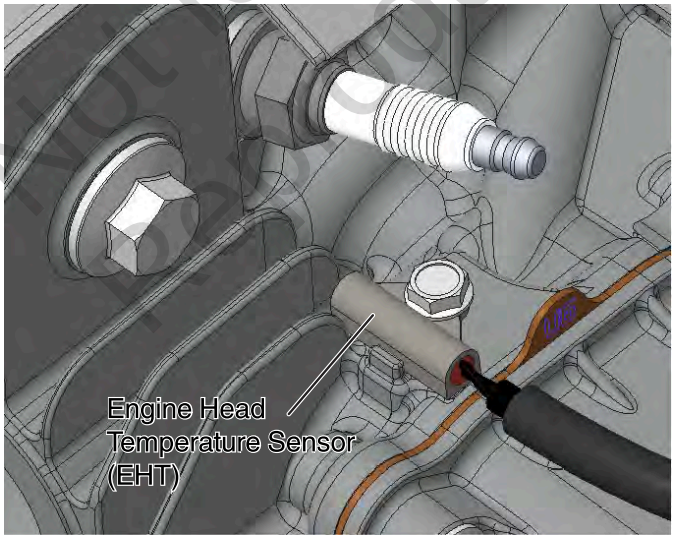
Possible FMIs - SPN 6805

The possible FMIs for SPN 6805 are as follows:

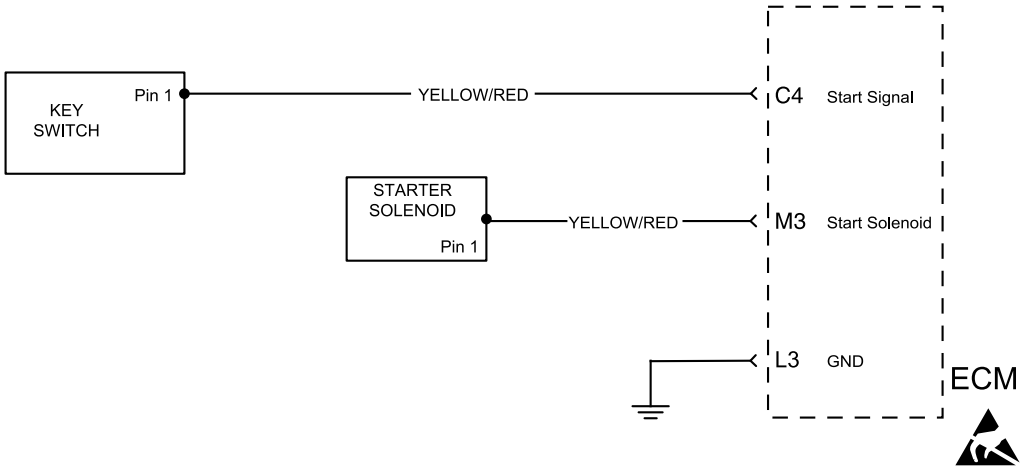
FMI	Description
16	Engine over temperature, engine speed derate

SPN 6805, FMI 16: Engine Over Temperature

Step	Action	Yes	No
1	Visually inspect the engine. Is the problem found?	Repair.	Proceed to step 2.
2	Check engine oil and oil level. Is oil level low?	Fill to proper level. See the engine operator manual.	Proceed to step 3.
3	Check ALL engine cooling system components. This includes: blower housing, fan, engine air guides, cylinder head air guides, cylinder head cooling fins, engine cooling fins. Is the problem found?	Clean engine cooling system components	Proceed to step 4.
4	Inspect internal engine components for damage. Is the problem found?	See your engine's repair manual for proper teardown and inspection procedures.	-



SPN 7753 Starter Motor Input Signal



Circuit Description

The ECM monitors the starter input command signal from the key switch to the ECM. When the key switch is in the START position, start voltage is sent from the key switch to the ECM. This triggers the ECM to command the starter motor solenoid to engage through the control circuit.

If the ECM receives a start signal request from the key switch for an excessive amount of time, SPN 7753 will be triggered, indicating an issue with the start signal request shorted high (FMI 3). The ECM then disables the output voltage commanded to the starter motor solenoid.

Possible FMIs - SPN 7753

The possible FMIs for SPN 7753 are as follows:

FMI	Description
3	Input signal shorted high

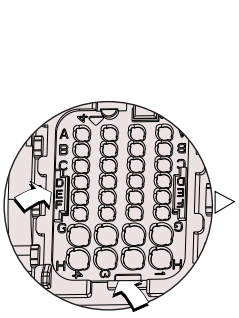
SPN 7753, FMI 3: Input Signal Shorted High

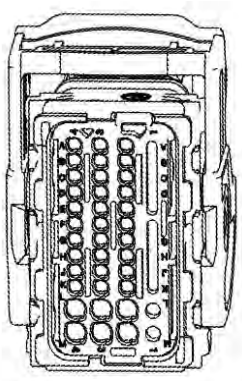
Step	Action	Yes	No
1	1. Turn ignition OFF. 2. Back probe terminal 1 (Yellow/Red wire) of the key switch electrical connector. 3. Connect terminal 1 back probe to red test lead on DVOM. 4. Connect black meter test lead to known good ground. 5. Set DVOM to read volts DC. 6. Disable the engine from starting by removing the ignition coil. See *SECTION 6 - REMOVAL AND INSTALLATION - Ignition Coil - Removal*. 7. Turn the ignition/key switch to the START, or cranking position. Does the DVOM read 12 VDC or above?	Proceed to Step 2.	Make sure the battery is connected and fully charged. Check for power between the battery and the operator panel connector (Red wire). Check for power between operator panel connector and key switch connector (Violet wires). Check 2 Amp fuse in the operator panel fuse block.
2	1. Turn the ignition/key switch to the START, or cranking position. Release the key switch to allow it to return to the RUN position. Does the DVOM continue to read 12 VDC or above?	Check wire between the key switch terminal 1 and ECM terminal M3 (Yellow/Red wire) for shorts. Replace as necessary and retest. If NO short is found and wire integrity is good, the short to high is within the key switch. See your engine's *Illustrated Parts List* for the correct replacement key switch/operator panel.	Problem does not exist.

SECTION 4 - WIRE HARNESS SCHEMATICS AND PIN-OUTS

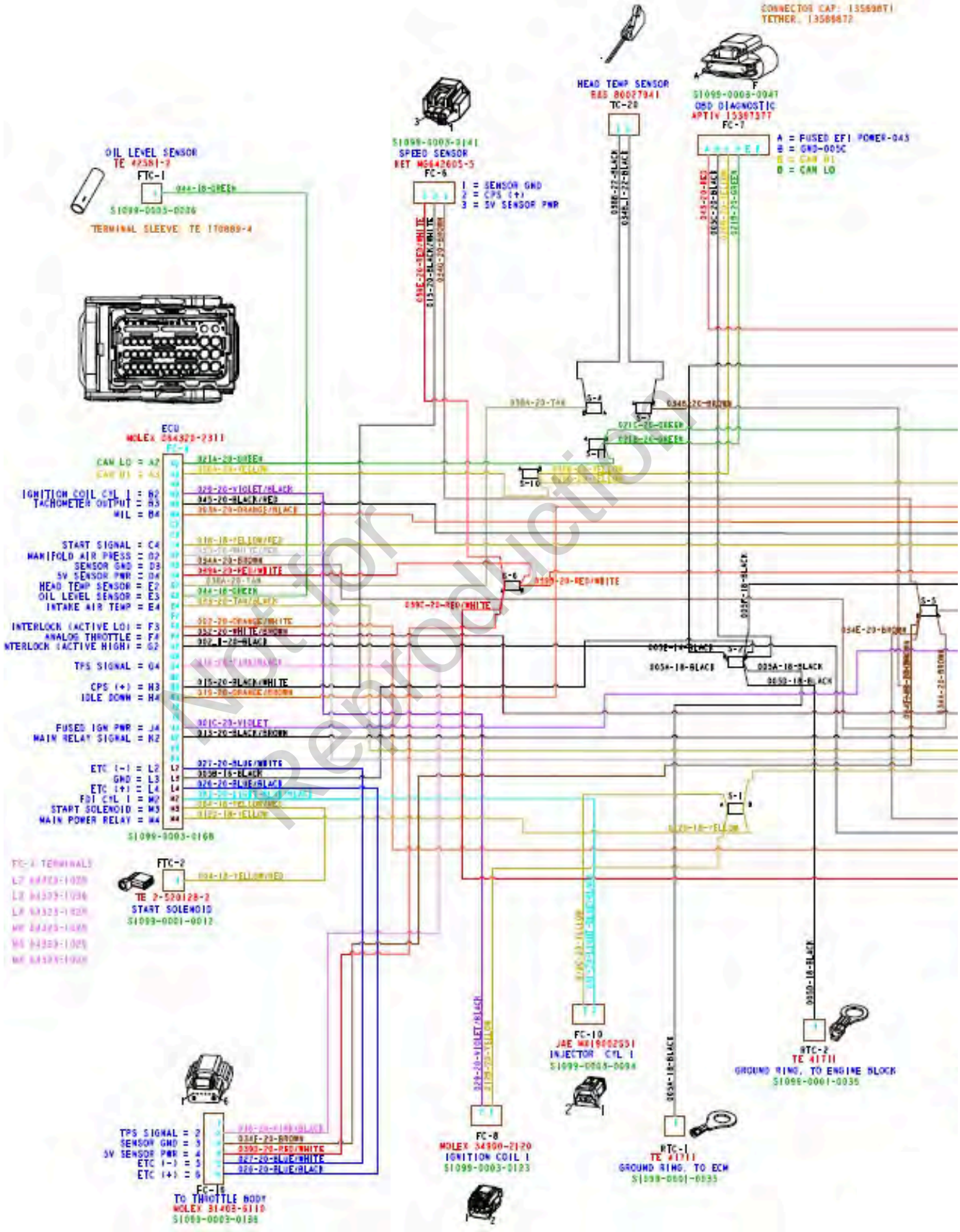
ECM Connector Pin-Out

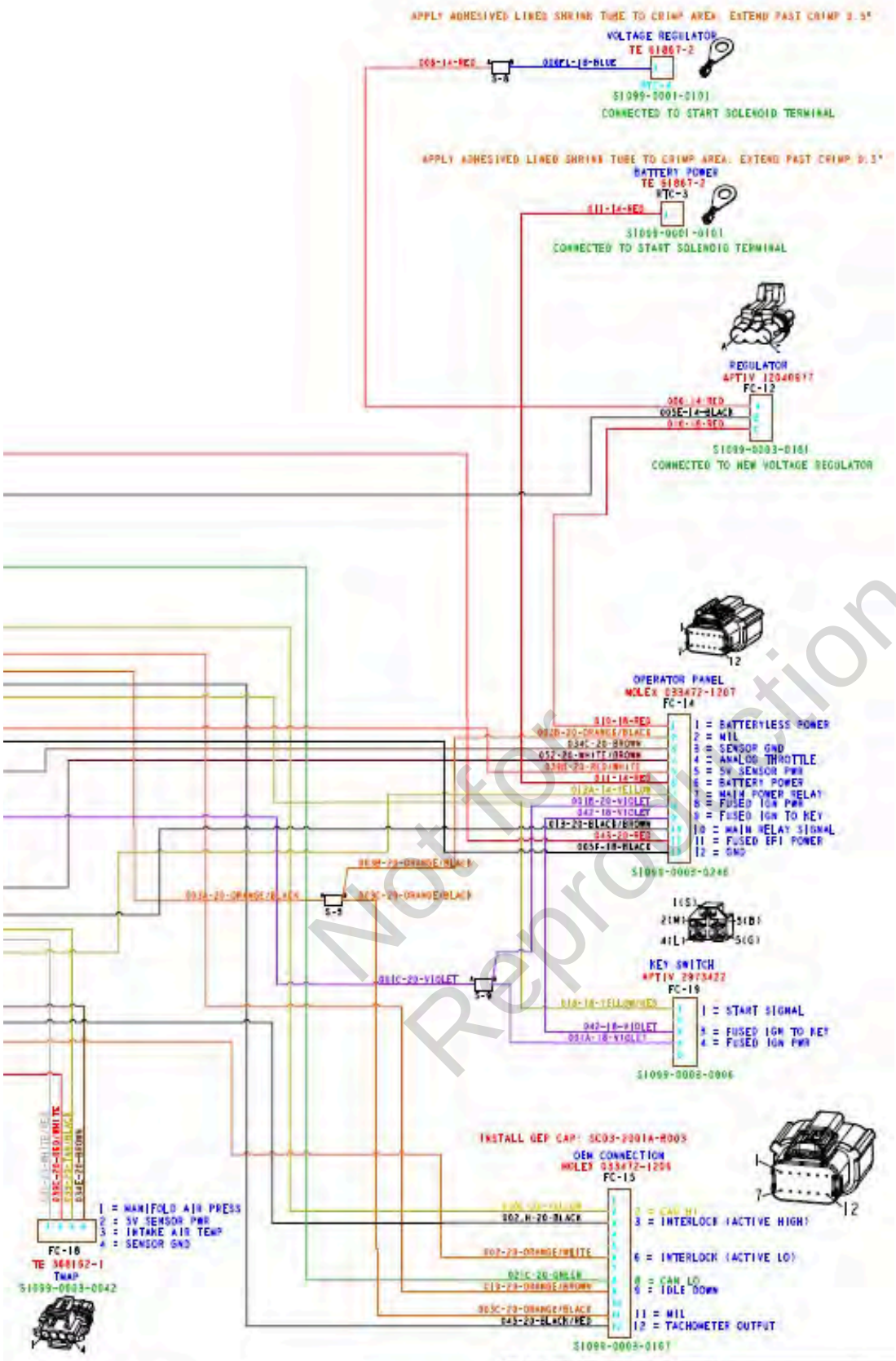
Connector Pin Number	Wire Color	Function
A2	Green	CAN LO
A3	Yellow	CAN HI
A4		
B2	Violet/Black	Ignition Coil
B3	Black/Red	Tachometer Output
B4	Orange/Black	MIL
C2		
C3		
C4	Yellow/Red	Start Signal
D2	White/Red	Manifold Air Pressure
D3	Brown	Sensor Ground
D4	Red/White	5V Sensor Power
E2	Tan	Cylinder Head Temperature Sensor
E3	Green	Oil Level Sensor
E4	Tan/Black	Intake Air Temperature
F2		
F3	Orange/White	Interlock (Active Lo)
F4	White/Brown	Analog Throttle
G2	Black	Interlock (Active Hi)
G3		
G4	Pink/Black	Throttle Position Sensor Signal
H2		
H3	Black/White	CPS (+)
H4	Orange/Brown	Idle Down
J2		
J3		
J4	Violet	Fused Ignition Power
K2	Black/Brown	Main Relay Signal
K3		
K4		
L2	Blue/White	ETC (-)
L3	Black	Ground
L4	Blue/Black	ETC (+)
M2	Light Blue/Black	FDI Cylinder 1
M3	Yellow/Red	Start Solenoid
M4	Yellow	Main Power Relay





25E300 Wiring Harness Diagram





SECTION 5 - SYMPTOMS AND TROUBLESHOOTING GUIDE

Introduction

Verify Customer Complaint

Verify customer complaint and then move to the Diagnostic Table that best describes the problem.

- Engine does not crank.
- Engine cranks but does not start.
- Engine exhibits hard start symptoms.
- Engine power output low.
- Engine hunts and surges.

Perform Visual Check

Each Diagnostic Table contains an instruction to perform a careful visual check. This check should always include the following:

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

Check electrical connectors for the following:

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

Perform General Engine Checks

- Inspect valves for proper valve lash adjustment. See your engine's repair manual.
- Inspect the spark plug condition and service if necessary. See *SECTION 6 - REMOVAL AND INSTALLATION - Spark Plug*.
- Inspect the fuel filter condition and service if necessary. See *SECTION 6 - REMOVAL AND INSTALLATION - Fuel Filter*.
- Inspect fuel condition. Replace with fresh.

Intermittents

IMPORTANT: Intermittents may not cause the MIL to illuminate or set a DTC. DO NOT use the DTC Tables to diagnose intermittent problems. The fault condition must be present to locate the problem. Many intermittent problems are caused by faulty electrical connections or wiring.The engine may be operated with a DVOM connected to the suspect circuit. If an abnormal voltage is observed when a malfunction occurs, it is a good indication that there is a fault in the circuit. The Diagnostic Tool also may be used to help detect intermittents. An intermittent MIL with no stored DTC may be caused by one or more of the following conditions:

- Ignition coil is shorted to ground and arcing is present at ignition wires or plugs.
- MIL wire to ECM is shorted to ground.
- Poor ECM grounds.
- An electrical system interference caused by a sharp electrical surge. The problem normally occurs when the faulty component is operated.
- Secondary ignition components are shorted to ground, or there is an open in the ignition coil ground.
- Engine components, such as starters, alternators or relays, are internally shorted to ground.

Preliminary Instructions

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

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

Engine Does Not Crank

Step	Action	Yes	No
1	Perform OBD System Check. Are any DTCs found?	Go to applicable DTC Table.	Go to step 2.
2	Perform a careful visual check. Is a problem found?	Repair	Go to step 3.
3	Check battery as follows: • Look for loose or corroded terminals. • Verify battery voltage is 12.2-13.5 volts. Is a problem found?	Repair	Go to step 4.
4	Verify PTO clutch is not engaged. Is PTO clutch engaged?	Disengage PTO clutch.	Go to step 5.
5	Verify safety interrupt is NOT active or faulty, if equipped. Is a problem found?	Repair	Go to step 6.
6	Verify ignition switch is working properly. See Repair Manual. Is a problem found?	Repair	Go to step 7.
7	Verify starter is operating properly. See Repair Manual. Is a problem found?	Repair	Go to step 8.
8	Review diagnostic procedures in this table. If all steps have been completed and no problems have been found, proceed as follows: • Repeat visual check. • Review Diagnostic Tool/Code Reader data. • Check all electrical connections within the suspect circuit and/or system. Is a problem found?	Repair	Contact engine manufacturer.

Engine Cranks But Does Not Start

Step	Action	Yes	No
1	Perform OBD System Check. Are any DTCs found?	Go to applicable DTC Table.	Go to step 2.
2	Perform a careful visual check. Is a problem found?	Repair	Go to step 3.
3	Verify fuel in tank(s). Is there insufficient fuel in tank(s)?	Go to step 4.	Add fuel.
4	Check fuel shut off valve, if equipped. Is fuel shut off valve closed?	Open fuel shut off valve.	Go to step 5.
5	Check the following fuel system components for dirt, water, or other contaminants. • Fuel tanks • Fuel filter • Fuel lines • Fuel pumps Is a problem found?	Repair	Go to step 6.
6	Verify that there is fuel flow flow from the mechanical fuel pump to the fuel injector. Is a problem found?	Repair	Go to step 7.
7	Verify safety interrupt is NOT active or faulty, if equipped. Is a problem found?	Repair	Go to step 8.
8	Check battery as follows: • Look for loose or corroded terminals. • Verify battery voltage is 12.2-13.5 volts. Is a problem found?	Repair	Go to step 9.
9	Verify that cylinder is getting spark. See Repair Manual. Is a problem found?	Repair	Go to step 10.
10	See *VERIFY ECM POWERS UP* in *SECTION 3 - TROUBLESHOOTING DTCs.* Is a problem found?	Repair	Go to step 11.
11	Check engine for the following mechanical problems: • Low compression/leak down. • Leaking cylinder head gaskets. • Proper valve set up. See Repair Manual. Is a problem found?	Repair	Go to step 12.
12	Review diagnostic procedures in this table. If all steps have been completed and no problems have been found, proceed as follows: • Repeat visual check. • Review Diagnostic Tool/Code Reader data. • Check all electrical connections within the suspect circuit and/or system. Is a problem found?	Repair	Contact engine manufacturer.

Engine Is Hard To Start

Definition: Engine cranks OK, but does not start for a long time. Engine does run, or may start but immediately die.

Step	Action	Yes	No
1	Perform OBD System Check. Are any DTCs found?	Go to applicable DTC Table.	Go to step 2.
2	Perform a careful visual check. Is a problem found?	Repair	Go to step 3.
3	Check the following fuel system components for dirt, water, or other contaminants. • Fuel tanks • Fuel filter • Fuel lines • Fuel pumps Is a problem found?	Repair	Go to step 4.
4	Verify that there is fuel flow flow from the mechanical fuel pump to the fuel injector. Is a problem found?	Repair	Go to step 5.
5	Check battery as follows: • Look for loose or corroded terminals. • Verify battery voltage is 12.2-13.5 volts. Is a problem found?	Repair	Go to step 6.
6	Check engine for the following mechanical problems: • Low compression. • Leaking cylinder head gaskets. • Proper valve set up. Is a problem found?	Repair	Go to step 7.
7	Review diagnostic procedures in this table. If all steps have been completed and no problems have been found, proceed as follows: • Repeat visual check. • Review Diagnostic Tool/Code Reader data. • Check all electrical connections within the suspect circuit and/or system. Is a problem found?	Repair	Contact engine manufacturer.

Engine Power Output Low

Step	Action	Yes	No
1	Perform OBD System Check. Are any DTCs found?	Go to applicable DTC Table.	Go to step 2.
2	Perform a careful visual check. Is a problem found?	Repair	Go to step 3.
3	Check the following fuel system components for dirt, water, or other contaminants. • Fuel tanks • Fuel filter • Fuel lines • Fuel pumps Is a problem found?	Repair	Go to step 4.
4	Verify that there is fuel flow flow from the mechanical fuel pump to the fuel injector. Is a problem found?	Repair	Go to step 5.
5	Verify crankcase oil is at the correct level. Is a problem found?	Add crankcase oil.	Go to step 6.
6	Verify air filter element is clean and dry. Is a problem found?	Replace air filter element.	Go to step 7.
7	Verify engine is not supporting a greater load than intended for its application? Check for the following: • Damaged drive belt. • For mowers, verify blades are not restricted by debris. • Faulty pulley bearing(s). Is a problem found?	Repair	Go to step 8.
8	Verify spark plug is: • Gapped properly. • Not gas fouled. • Not excessively worn. Is a problem found?	Repair	Go to step 9.
9	Verify exhaust is not restricted. Is a problem found?	Repair	Go to step 10.
10	Check engine for the following mechanical problems: • Low compression. • Leaking cylinder head gaskets. • Proper valve set up. See Repair Manual. Is a problem found?	Repair	Go to step 11.

11	Review diagnostic procedures in this table. If all steps have been completed and no problems have been found, proceed as follows: • Repeat visual check. • Review Diagnostic Tool/Code Reader data. • Check all electrical connections within the suspect circuit and/or system. Is a problem found?	Repair	Contact engine manufacturer.

Engine Hunts and Surges

Step	Action	Yes	No
1	Perform OBD System Check. Are any DTCs found?	Go to applicable DTC Table.	Go to step 2.
2	Perform a careful visual check. Is a problem found?	Repair	Go to step 3.
3	Check the following fuel system components for dirt, water, or other contaminants. • Fuel tanks • Fuel filter • Fuel lines • Fuel pumps Is a problem found?	Repair	Go to step 4.
4	Verify that there is fuel flow flow from the mechanical fuel pump to the fuel injector. Is a problem found?	Repair	Go to step 5.
5	Check battery as follows: • Look for loose or corroded terminals. • Verify battery voltage is 12.2-13.5 volts. Is a problem found?	Repair	Go to step 6.
6	Verify crankcase oil is at the correct level. Is a problem found?	Add crankcase oil.	Go to step 7.
7	Verify air filter element is clean and dry. Is a problem found?	Replace air filter element.	Go to step 8.
8	Review diagnostic procedures in this table. If all steps have been completed and no problems have been found, proceed as follows: • Repeat visual check. • Review Diagnostic Tool/Code Reader data. • Check all electrical connections within the suspect circuit and/or system. Is a problem found?	Repair	Contact engine manufacturer.

SECTION 6 - REMOVAL AND INSTALLATION

Preliminary Instructions

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

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

Front Cover Panel

Depending on your engine's trim, the front cover panel style is based on the style of air cleaner assembly. All front cover panels attach to the engine in the same manner unless noted within the procedure.

Front Cover Panel - Removal

1. Starting at the front of the engine, remove the three front panel mounting fasteners (**A-C**, Figure 9).

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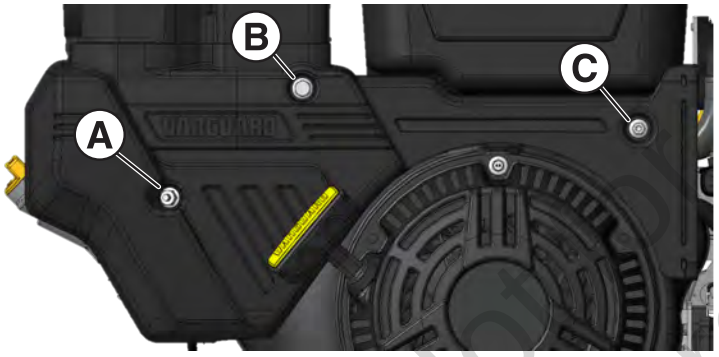

2. If equipped with either a low profile air cleaner or remote air cleaner assembly, remove the upper panel fastener (**A**, Figure 10).

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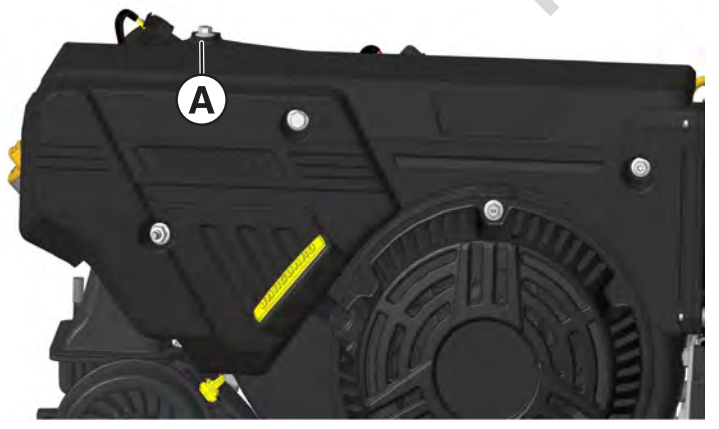

3. If equipped with an operator's panel, remove the two fasteners (**A**, Figure 11) that secure the front panel to the operator's panel.

11

NOTE: The two fasteners that secure the front panel to the operator's panel make use of captive nuts within the front cover panel. Make sure that the captive nuts do not fall out during removal. Reinstall into channel if necessary.

4. Remove the front cover panel from the engine and set aside.

NOTE: If equipped with remote air cleaner assembly, it may be necessary to remove the air cleaner hose from the front cover. Consult your equipment repair manual for proper procedures.

Front Cover Panel - Installation

1. Install the front cover panel onto the engine.
2. Start by hand the three front cover panel fasteners (**A-C**, Figure 9). Tighten **A** to **30 lb-in** (3.4 Nm). Tighten **B-C** to **50 lb-in** (5.6 Nm).
3. If equipped with a low mount or remote air cleaner assembly, start by hand the upper front cover fastener (**A**, Figure 10). Tighten to **50 lb-in** (5.6 Nm).
4. If equipped with operator's panel, start by hand the two panel fasteners (**A**, Figure 11). Tighten to **50 lb-in** (5.6 Nm).

Air Cleaner Assembly

Depending on your engine's trim, the air cleaner assembly may be high-mount, low-mount or remote. If equipped with the high-mount air cleaner, proceed to *Air Cleaner Assembly - High Mount - Removal* and *Installation.* If equipped with the low-mount air cleaner assembly, proceed to *Air Cleaner Assembly - Low Mount - Removal* and *Installation*. If equipped with a remote air cleaner assembly, consult your equipment repair manual for service and replacement procedures.

Air Cleaner Assembly - High Mount - Removal

1. See *Front Cover Panel - Removal*.
2. Undo the two air cleaner cover retaining fasteners (**A**, Figure). Remove cover.
3. Remove the air filter from the air cleaner base. Inspect, clean or replace as necessary.
4. Remove the air cleaner/ignition coil heat shield mounting fastener (**A**, Figure 12).

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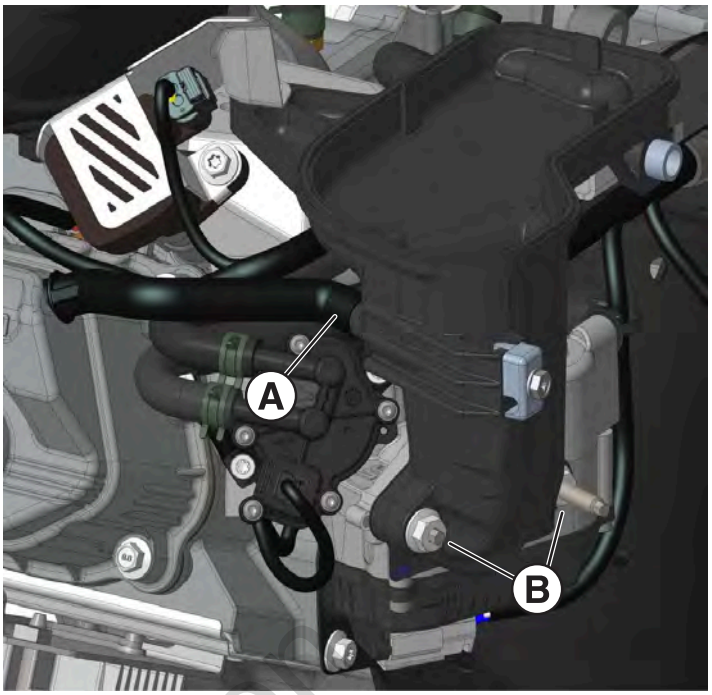
5. Remove the valve cover breather hose from the air cleaner base port (**A**, Figure 13).

13



6. Remove the two air cleaner base mounting fasteners from the mounting studs (**B**).
7. Remove the air cleaner base and gasket from the throttle body. Discard old gasket.

Air Cleaner Assembly - High Mount - Installation

1. Prior to assembly and installation, make sure that all mating and gasket surfaces are clean, dry and free from contamination.
2. Install the **new** air cleaner base gasket onto the alignment pins of the flange. Make sure the orientation of the gasket matches the profile of the air cleaner flange. See Figure 14.

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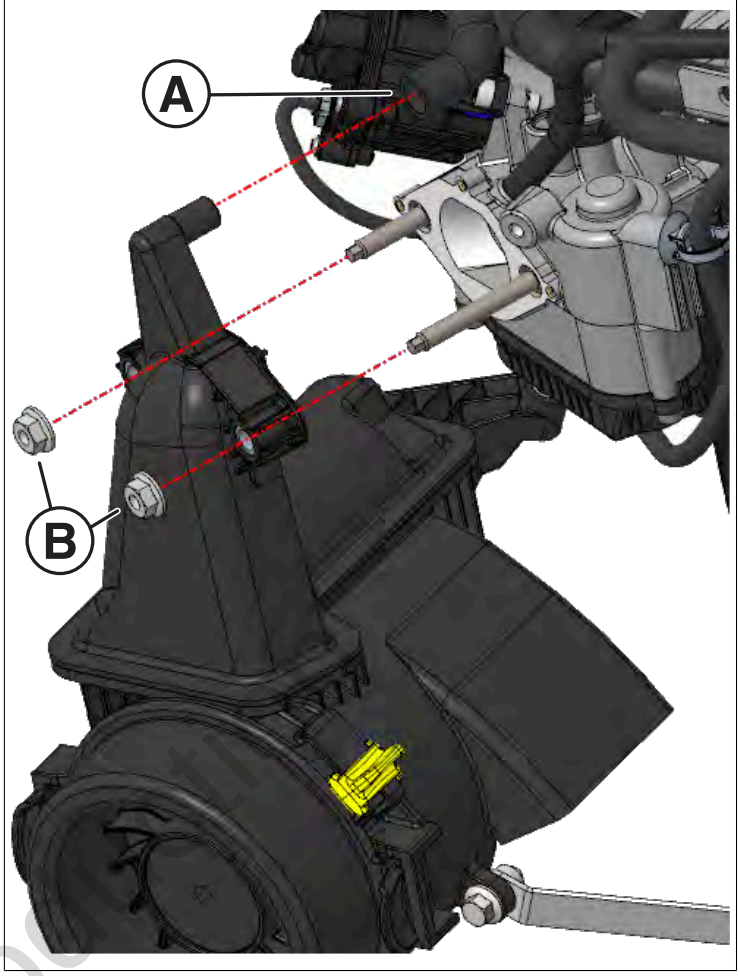
3. Install the air cleaner base with gasket onto the throttle body mounting studs. When installing the air cleaner base, the top mounting flange must be located underneath the ignition coil heat shield.
4. Start by hand the two air cleaner base to throttle body fasteners (**B**, Figure 13). Tighten to **40 lb-in** (4.5 Nm).
5. Start by hand the upper air cleaner fastener (**A**, Figure 12). Tighten to **95 lb-in** (10.7 Nm).
6. Install the valve cover breather hose onto the air cleaner base port (**A**, Figure 13).
7. Install air cleaner into air cleaner base.
8. Install air cleaner cover. Turn clockwise by hand the two air cleaner cover fasteners until snug.

Air Cleaner Assembly - Low Mount - Removal

1. See *Front Cover Panel - Removal*.
2. If servicing the air filter, unclip the air cleaner cover retaining clips and remove cover from air cleaner base.
3. Remove air filter from air cleaner base and inspect. Clean or replace as necessary.
4. Remove the valve cover breather hose from the air cleaner base port (**A**, Figure 15).

15



5. Remove the lower air cleaner support bracket fastener (**A**, Figure 16).

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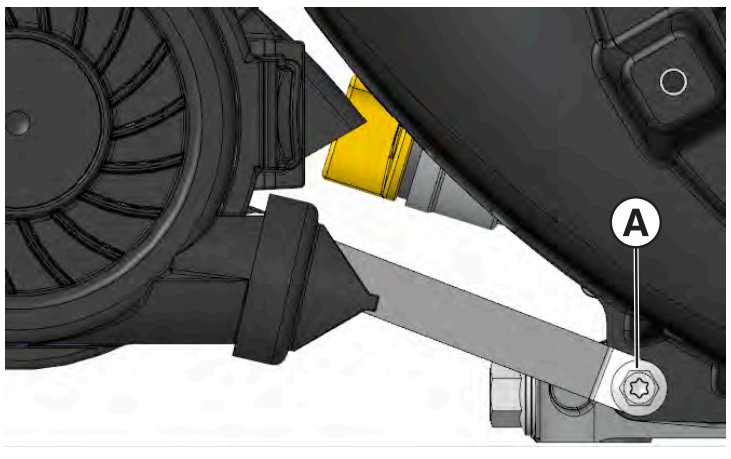

6. Remove the rear air cleaner mounting fastener (**A**, Figure 17).

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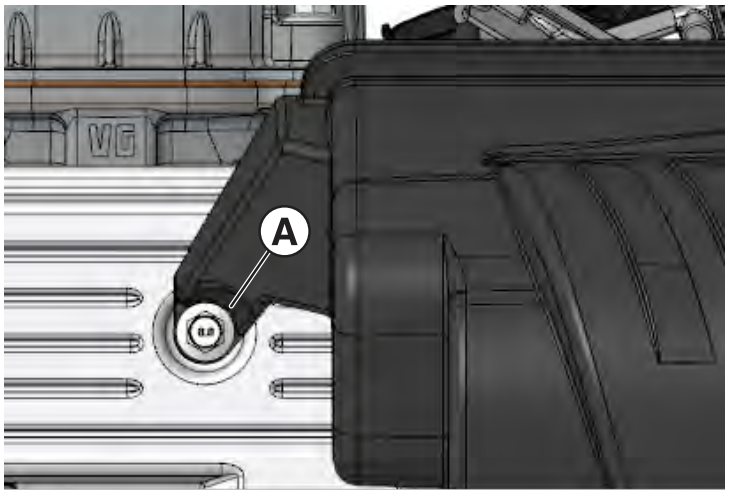

7. Remove the two air cleaner base to throttle body fasteners (**B**, Figure 15).
8. Remove the air cleaner assembly and gasket from the throttle body. Discard **old** gasket.

Air Cleaner Assembly - Low Mount - Installation

1. Prior to assembly and installation, make sure that all mating and gasket surfaces are clean, dry and free from contamination.
2. Install the **new** air cleaner base gasket onto the alignment pins of the flange. Make sure the orientation of the gasket matches the profile of the air cleaner flange. See Figure .

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3. Install the air cleaner assembly onto the throttle body mounting studs.
4. Start by hand the two air cleaner to throttle body fasteners (**B**, Figure 15). Tighten to **40 lb-in** (4.5 Nm).
5. Start by hand the lower support bracket fastener (**A**, Figure 16). Tighten to **95 lb-in** (10.7 Nm).
6. Start by hand the rear air cleaner mounting fastener (**A**, Figure 17). Tighten to **50 lb-in** (5.6 Nm).
7. Install the valve cover breather hose onto the air cleaner port (**A**, Figure 15).
8. If removed, install the air filter into the air cleaner base.
9. Install the air cleaner cover. Engage the cover retaining clips to secure.

Rewind Starter

Depending on your engine's trim, the rewind handle position may be located at the 8, 10, 12 or 2 O'clock position. Prior to disassembly, note the position on your engine. Failure to install the rewind starter in the proper position may inhibit operation.

Rewind Starter - Removal

1. Remove the three fasteners that secure the rewind starter to the blower housing (**A-C**, Figure 19).

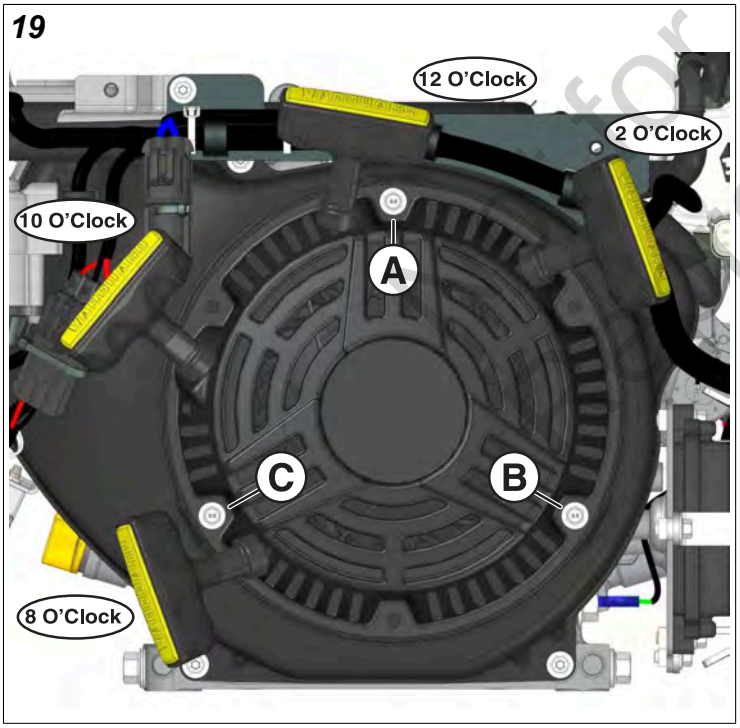
NOTE: Depending on your engine's trim, the rewind starter may be mounted with the handle in 8, 10, 12, or 2 O'clock position (see Figure 19 as a reference). Before removal of the rewind starter mechanism, make sure the handle position is noted for proper installation.

2. Remove the rewind starter from the blower housing and set aside.

Rewind Starter - Installation

1. Align the rewind starter on the blower housing in the position noted from removal.
2. Start by hand the three rewind starter fasteners (**A-C**, Figure 19). Tighten to **30 lb-in** (3.4 Nm).

19

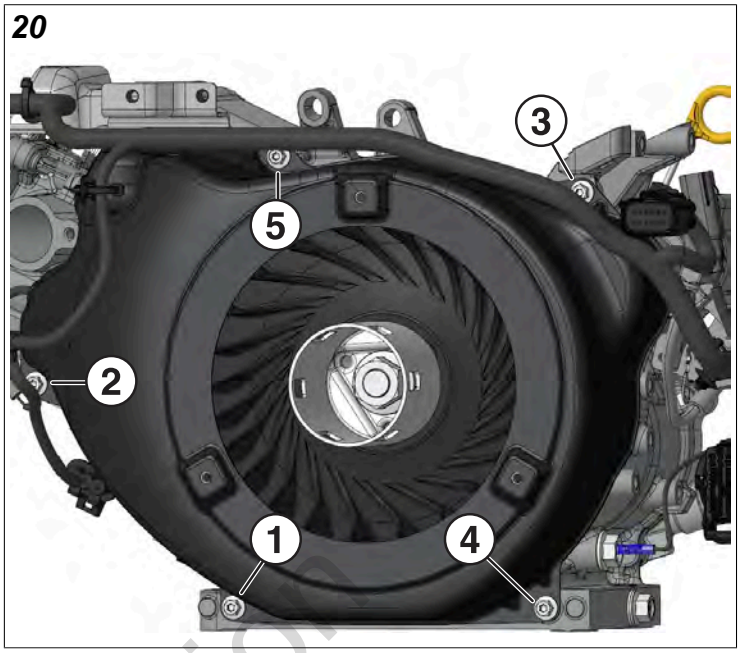


Blower Housing

Blower Housing - Removal

1. Remove front cover panel, see *Front Cover Panel - Removal*.
2. Remove air cleaner assembly, see *Air Cleaner Assembly - Removal*.
3. Remove electronic throttle control (ETC), see *Electronic Throttle Control (ETC) - Removal*.
4. Remove rewind starter, see *Rewind Starter - Removal*.
5. Remove the five blower housing to engine block fasteners (**1-5**, Figure 20) in the order as shown.

20



6. Remove blower housing from engine and set aside.

Blower Housing - Installation

1. Install the blower housing onto the engine.
2. Route the speed sensor wire through the recessed area on the blower housing next to the ETC.
3. Start by hand the five blower housing fasteners. Tighten, in the sequence shown in Figure 20 to **95 lb-in** (10.7 Nm).

Side Cover

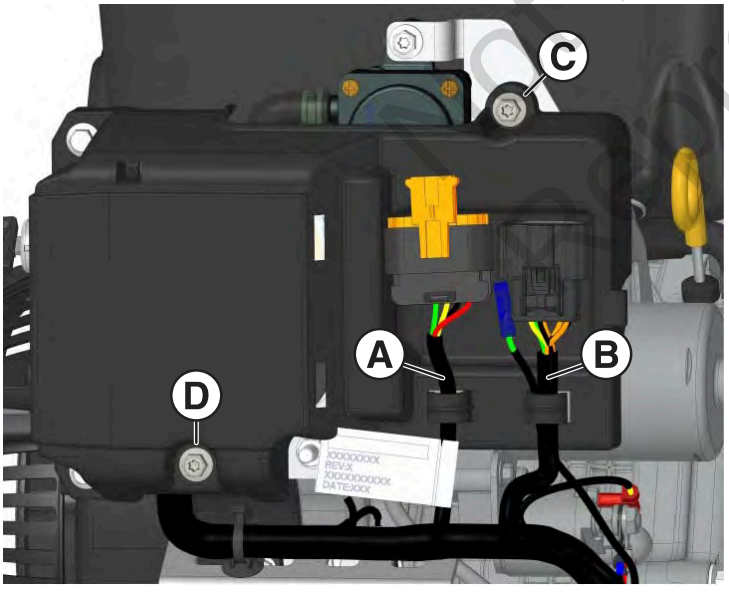
Side Cover - Removal

1. Remove the connector cover from the side cover. Lift the tab of the snap latch (**A**, Figure 21) and rotate the cover away from the engine to remove.

21

2. Remove the DLC (**A**, Figure 22) and equipment connector (**B**) from the wire harness clips.

22



3. Remove the upper operator panel to side cover fastener (**A**, Figure 23).

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4. Remove the two side cover to mounting bracket fasteners (**C-D**, Figure 22).
5. Remove the side cover from the engine and set aside.

Side Cover - Installation

1. Install the side cover onto the mounting bracket and rear of operator panel. Make sure that the side cover alignment tab is located BEHIND the operator panel.
2. Start by hand the two side cover to mounting bracket fasteners (**C-D**, Figure 22). Tighten to **50 lb-in** (5.6 Nm).
3. Start by hand the operator panel to side cover fastener (**A**, Figure 23). Tighten to **50 lb-in** (5.6 Nm).
4. Secure the DLC to the side cover wire harness clip (**A**, Figure 22).
5. Secure the equipment connector to the side cover wire harness clip (**B**, Figure 22).

NOTE: Depending on your engine's trim, the oil level sensor wire is retained by the equipment connector harness clip.

6. Install the connector over by inserting the cover tabs into the two slots on the side cover. Rotate the connector cover toward the side cover until the snap latch (**A**, Figure 21) is engaged and "clicks" into place.

Operator Panel

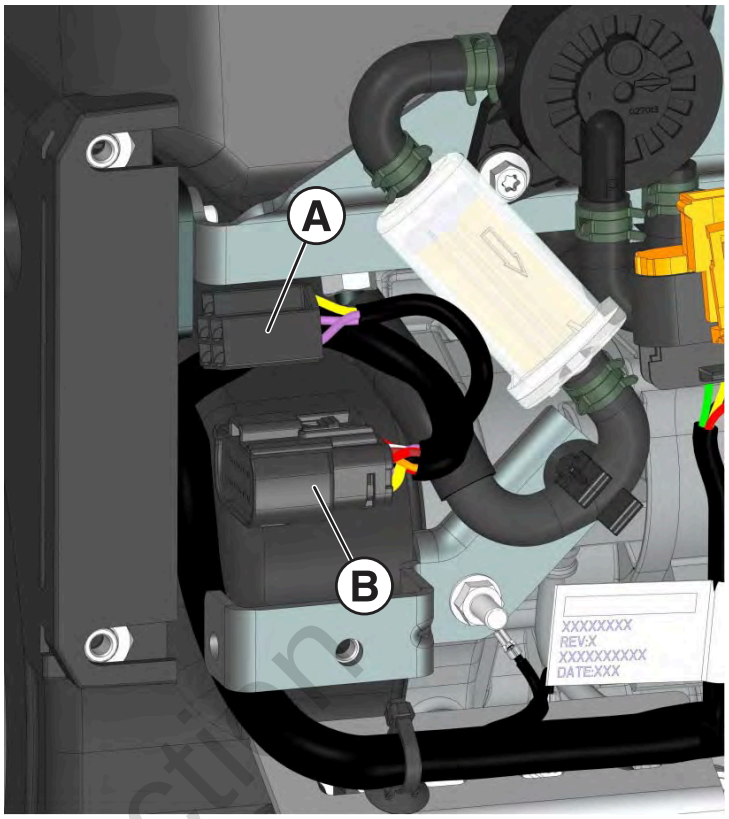
Operator Panel - Removal

1. Remove the four operator panel fasteners (**A-D**, Figure 24).

24

2. Pull the operator panel away from the engine to access the rear electrical connectors.
3. Disconnect the key switch electrical connector from the rear of the operator panel (**A**, Figure 25).

25



4. If equipped, disconnect the speed control electrical connector from the rear of the operator panel (**B**).
5. Remove the operator panel from the engine and set aside.

Operator Panel - Installation

1. Connect the key switch harness connector (**A**, Figure 25) to the key switch at the rear of the panel. Press onto key switch until it "clicks" into place.
2. If equipped, connect the speed control harness connector (**B**) to the speed control switch at the rear of the panel. Press onto speed control switch until it "clicks" into place.
3. Install the operator panel onto the engine.
4. Start by hand the four panel fasteners (**A-D**, Figure 24). Tighten to **50 lb-in** (5.6 Nm).

Fuel Tank

Depending on your engine's trim, the fuel tank may be remotely mounted on the equipment. Consult your equipment repair manual for proper procedures. If your engine is equipped with a fuel tank mounted atop the engine, proceed as follows.

Fuel Tank - Removal

1. Drain the fuel tank by running the engine until the tank is empty.
2. Remove front cover panel. See *Front Cover Panel - Removal*.
3. Starting at the front of the engine (blower housing side), remove the front fuel tank fastener (**A**, Figure 26).

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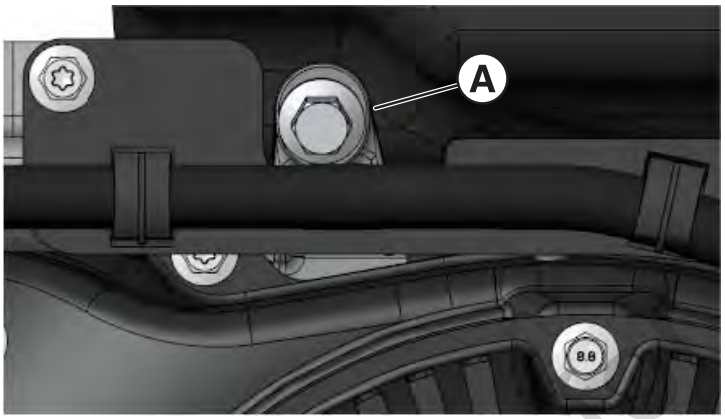

4. At the rear of the engine (PTO side), remove the rear fuel tank fastener (**A**, Figure 27).

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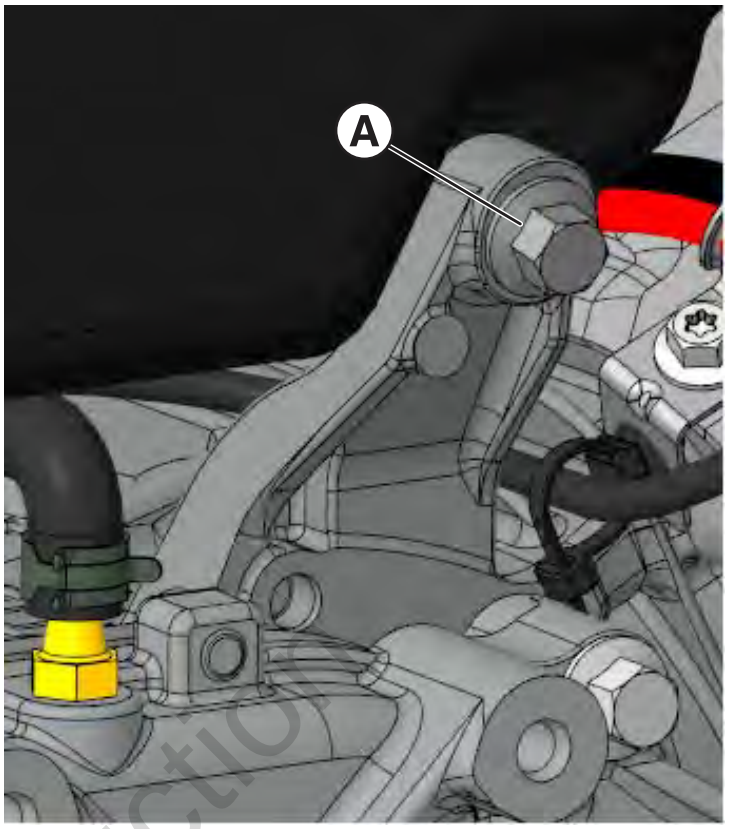
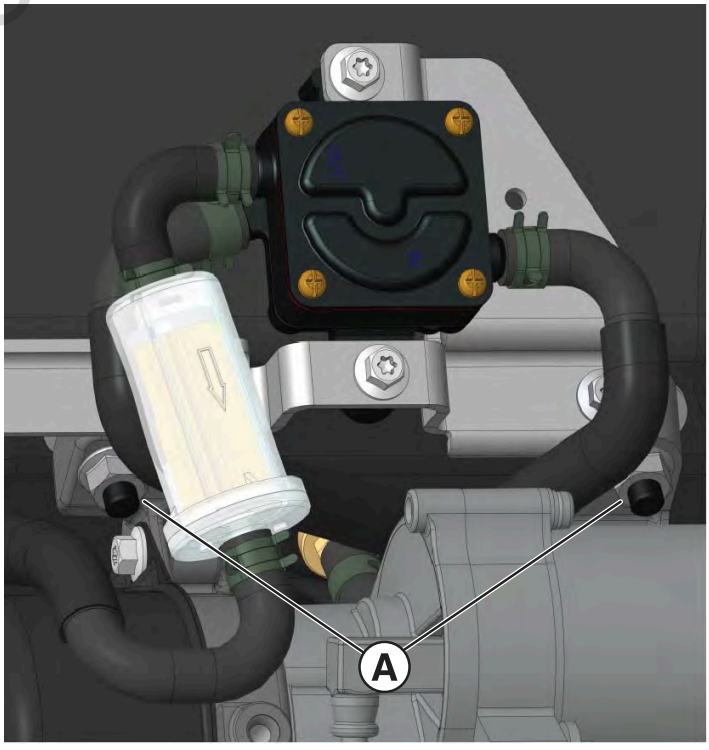


5. At the side of the engine (starter motor side), remove the two side fuel tank fasteners (**A**, Figure 28).

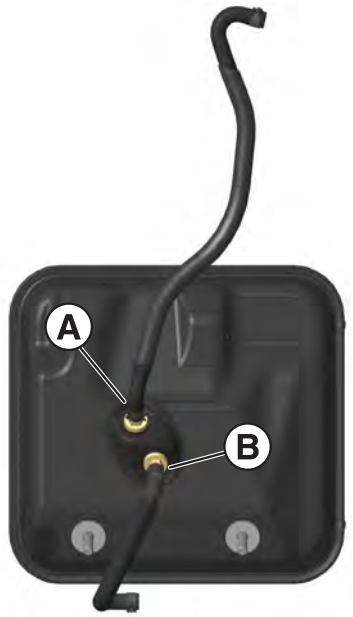
28



6. Lift the fuel tank vertically to access the fuel lines.

7. Disconnect the fuel return hose (**A**, Figure 29) at the fuel tank. Squeeze the tangs of the fuel line clamp and slide the clamp along the fuel hose away from the tank.

29



8. Obtain a fuel line removal tool.
9. Using the fuel line removal tool, disconnect the fuel return line from the fuel tank port.

NOTE: Some residual fuel may remain in the fuel line and fuel injector. Wrap the line in a rag or shop towel to catch any spilled fuel. Dispose of spilled fuel in the proper receptacle.

10. Disconnect the fuel supply line (**B**) at the fuel tank. Squeeze the tangs of the fuel line clamp and slide the clamp along the fuel hose away from the tank.
11. Using the fuel line removal tool, disconnect the fuel supply line from the fuel tank port.

NOTE: Some residual fuel may remain in the fuel line and fuel pump. Wrap the line in a rag or shop towel to catch any spilled fuel. Dispose of spilled fuel in the proper receptacle.

12. Lift the fuel tank vertically away from the engine and set aside.

NOTE: The 2 fuel tank mounting studs make use of washers between the tank and tank mount. Retain washers for use in reassembly.

13. Dispose of any spilled or remaining fuel in the proper receptacle.

Fuel Tank - Installation

1. Orient the fuel tank so that the side with the mounting studs faces the starter motor side of the engine.
2. Connect the fuel supply hose (**B**, Figure 29) to the supply port on the fuel tank.
3. Squeeze the tangs on the fuel hose clamp and slide the clamp along the hose until it is positioned above the tank port and **1/8 inch** (3 mm) from the end of the hose.
4. Connect the fuel return hose (**A**) to the return port on the fuel tank.
5. Squeeze the tangs of the fuel hose clamp and slide the clamp along the hose until it is positioned above the injector port and **1/8 inch** (3 mm) from the end of the hose.
6. Lower the fuel tank onto the engine, with the mounting studs and passing through the fuel tank mounting bores.

NOTE: The two fuel tank mounting studs use washers placed between the fuel tank and the mounting posts. See **A**, Figure 30.

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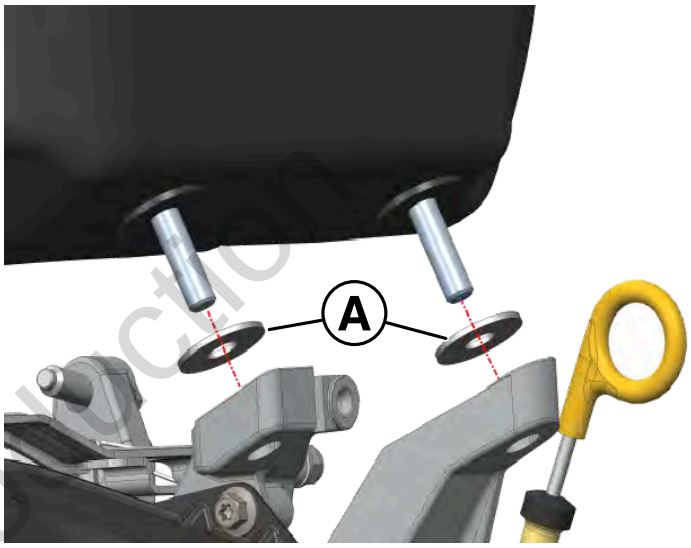


7. Start by hand the two side (starter motor side) fuel tank mounting fasteners (**A**, Figure 28).
8. Start by hand the rear (PTO side) fuel tank mounting fastener (**A**, Figure 27).
9. Start by hand the front (blower housing side) fuel tank fastener (**A**, Figure 26).
10. Using a crisscross pattern starting with the front-of-engine fuel tank fastener, tighten each fuel tank mounting fastener to **160 lb-in** (18 Nm).

Fuel Hoses

Fuel Supply Hoses - Removal

The fuel supply consists of three hoses: a fuel tank to fuel pump hose, a pulse pump to fuel filter hose, and a fuel filter to fuel injector hose.

Depending on your engine's trim, the fuel tank may be engine or remote mounted. The procedure that follows applies to all engine specifications unless specifically noted.

Prior to servicing the fuel hoses of the engine, make sure to drain all fuel from the fuel tank.

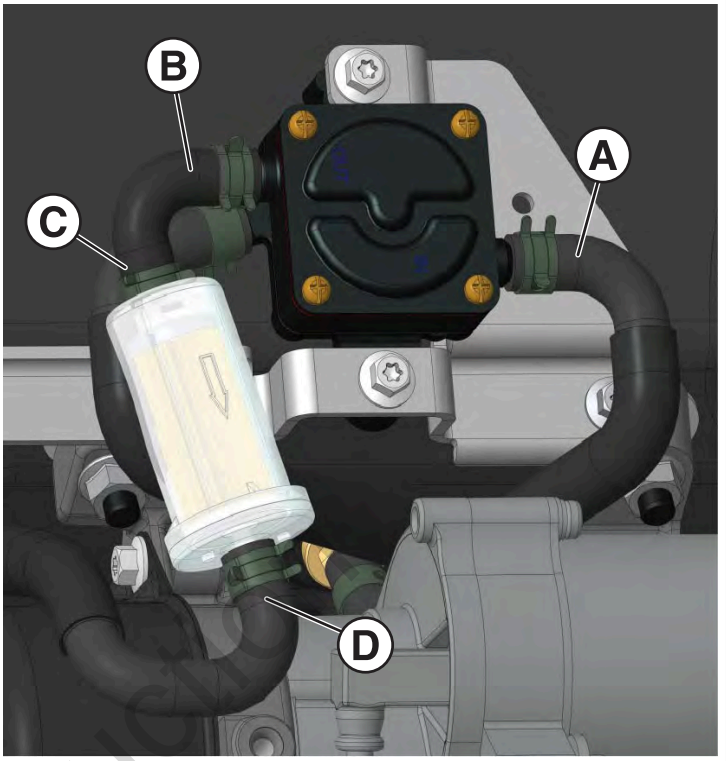
Fuel Tank to Fuel Pump Hose

1. Remove engine side cover. See *Side Cover - Removal*.
2. If equipped with engine mounted fuel tank, remove fuel tank. See *Fuel Tank - Removal*.
3. Disconnect the fuel supply hose from the fuel tank. Squeeze the tangs of the hose clamp and slide the clamp along the hose away from the tank. Using the fuel line removal tool, remove the fuel line from the fuel tank port.

NOTE: Some residual fuel may remain in the fuel tank and fuel hoses. Wrap hoses and ports with a rag or shop towel to prevent spills. Clean up any spilled fuel and dispose of in the appropriate receptacle.

4. Disconnect the fuel supply hose from the fuel pump (**A**, Figure 31). Squeeze the tangs of the hose clamp and slide the clamp along the hose away from the pump. Using the fuel line removal tool, remove the fuel line from the fuel pump port.

31



5. Feed the fuel supply line under the fuel pump mounting bracket to remove from engine.

Fuel Pump to Fuel Filter Hose

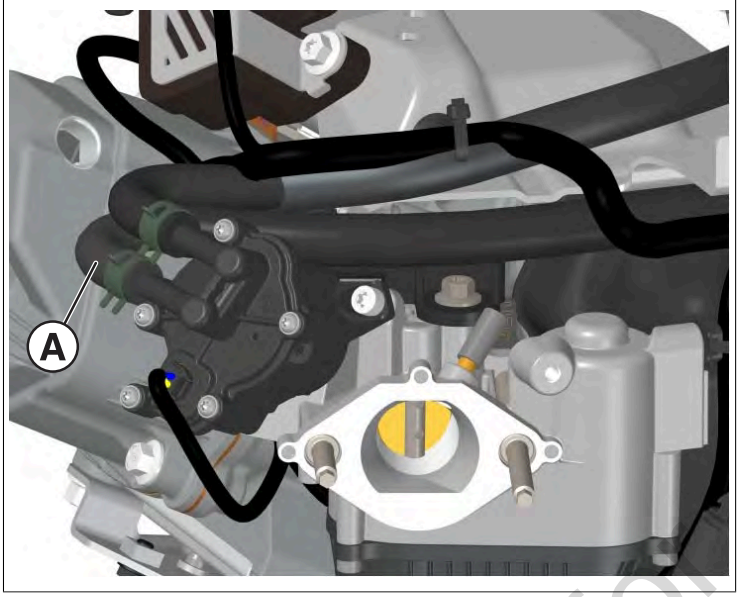
1. Remove engine side cover. See *Side Cover - Removal*.
2. Disconnect the fuel supply line from the fuel pump (**B**, Figure 31). Squeeze the tangs of the hose clamp and slide the clamp along the hose away from the pump. Using the fuel line removal tool, remove the fuel line from the fuel pump port.
3. Disconnect the fuel supply hose from the top fuel filter port (**C**). Squeeze the tangs of the hose clamp and slide the clamp along the hose away from the filter. Using the fuel line removal tool, remove the fuel line from the fuel filter port.

Fuel Filter to Fuel Injector Supply Hose

1. Remove engine side cover. See *Side Cover - Removal*.
2. Remove engine front cover panel. See *Front Cover Panel - Removal*.
3. If equipped, remove air cleaner assembly. See *Air Cleaner Assembly - Removal*.

4. Disconnect the fuel supply hose from the bottom fuel filter port (**D**, Figure 31). Squeeze the tangs of the hose clamp and slide the clamp along the hose away from the filter. Using the fuel line removal tool, remove the fuel line from the fuel filter port.
5. Disconnect the fuel supply hose from the fuel injector (**A**, Figure 32). Squeeze the tangs of the hose clamp and slide the clamp along the hose away from the filter. Using the fuel line removal tool, remove the fuel line from the injector port.

32



6. Feed the fuel supply hose away from the fuel injector and underneath the cylinder air guide.
7. Continue to feed the fuel line over the top of the blower housing and underneath the fuel pump mounting bracket to remove fully from engine.

Fuel Supply Hoses - Installation

Fuel Filter to Fuel Injector Hose

1. Starting on the starter motor side of the engine, feed the fuel line underneath the fuel pump mounting bracket and over the top of the blower housing.
2. Continue to feed the fuel line underneath the cylinder head air guide until the end of the fuel hose reaches the fuel injector.
3. Install the fuel hose clamps onto the ends of the fuel supply hose. Slide clamp each down the hose away from the hose ends.
4. Press the fuel supply hose onto the fuel injector supply port until the end of the hose meets the port flange (**A**, Figure 32).

NOTE: The fuel injector ports are labeled with arrows that indicated the direction of fuel flow. The arrow pointing toward the injector body indicates the fuel supply port, and the arrow pointing away from the injector body indicates the fuel return port.

5. Squeeze the tangs of the fuel hose clamp and slide hose clamp over the injector port until it is **1/8 inch** (3 mm) from end of hose.
6. Press the fuel supply hose onto the fuel filter port until the end of the hose meets the port flange (**D**, Figure 31).
7. Squeeze the tangs of the fuel hose clamp and slide hose clamp over the fuel filter port until it is **1/8 inch** (3 mm) from end of hose.

Fuel Pump to Fuel Filter Hose

1. Install the fuel hose clamps onto the ends of the fuel hose. Slide the clamps along the hose and away from the ends.
2. Press the fuel hose onto the fuel filter port until the end of the hose meets the filter port flange (**C**, Figure 31).
3. Press the fuel hose onto the fuel pump port until the end of the hose meets the pump port flange (**B**, Figure 31).
4. Squeeze the tangs of the fuel hose clamp and slide clamp along hose until positioned above the fuel filter port, approximately **1/8 inch** (3 mm) from end of hose. Repeat this procedure for the fuel pump side of the hose.

Fuel Tank to Fuel Pump Hose

1. Install the fuel hose clamps onto the ends of the fuel hose. Slide the clamps along the hose and away from the ends.
2. Press the fuel hose onto the fuel pump port until the end of the hose meets the pump port flange (**A**, Figure 31).
3. Feed the fuel hose underneath the fuel pump mounting bracket toward the center of the engine.
4. Press the fuel hose onto the fuel tank port until the end of the hose meets the tank port flange.
5. Squeeze the tangs of the fuel hose clamp and slide clamp along hose until positioned above the fuel pump port, approximately **1/8 inch** (3 mm) from end of hose. Repeat this procedure for the fuel tank side of the hose.

If fuel return and vent hose service is required, proceed to the appropriate instructions. If fuel hose service is complete, install the following:

1. If equipped, install fuel tank. See *Fuel Tank - Installation*.
2. Install air cleaner assembly. See *Air Cleaner Assembly - Installation*.
3. Install front cover panel. See *Front Cover Panel - Installation*.
4. Install side cover. See *Side Cover - Installation*.

Fuel Return Hose - Removal

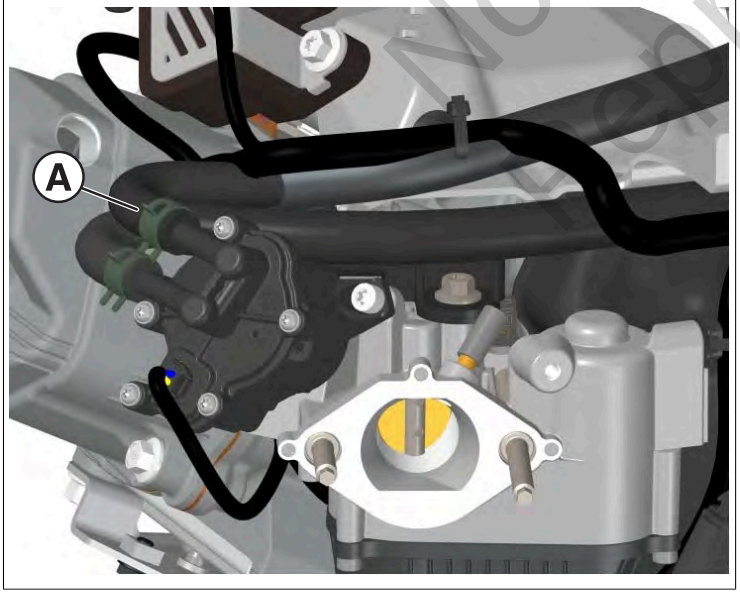
The fuel return hose takes unused fuel from the fuel injector and returns it to the fuel tank for reuse. On engines equipped with an engine mounted fuel tank, the fuel return line connects between the fuel injector return port and the return port on the bottom of the fuel tank. On engines where a remote fuel tank is used, the fuel return line connects between the fuel return port on the fuel injector and the return port on the remote fuel tank. Consult your equipment's repair manual for proper the procedure to disconnect the fuel return hose from the remote fuel tank.

1. Remove front cover panel. See *Front Cover Panel - Removal*.
2. If required, remove air cleaner assembly. See *Air Cleaner Assembly - Removal*.
3. If equipped, remove fuel tank. See *Fuel Tank - Removal*.
4. Disconnect the fuel return hose from the fuel tank. Squeeze the tangs of the hose clamp and slide the clamp along the hose away from the end of hose.
5. Using the fuel line removal tool, remove the fuel return hose from the fuel tank.

NOTE: Some residual fuel may be present in the fuel tank, fuel lines and fuel injector. Wrap hoses and component ports in a rag or shop towel to prevent fuel spillage. Clean up any spilled fuel and dispose of in the proper receptacle.

6. Disconnect the fuel return hose from the fuel injector (**A**, Figure 33). Squeeze the tangs of the hose clamp and slide the clamp along the hose away from the end of hose.

33



7. Using the fuel line removal tool, remove the fuel return hose from the injector.
8. Feed the fuel hose underneath the wire harness to remove from engine.

NOTE: On some engines with a remote fuel tank, the fuel return hose can be routed underneath the cylinder head air guide. Feed the fuel hose underneath the air guide to remove from engine.

Fuel Return Hose - Installation

1. If equipped with a remote fuel tank, feed the fuel return hose underneath the cylinder head air guide toward the fuel injector.
2. Continue to feed the fuel return hose underneath the engine wire harness until the end of the fuel hose reaches the fuel injector.
3. Install the fuel hose clamps onto the ends of the fuel return hose. Slide clamp each down the hose away from the hose ends.
4. Press the fuel return hose onto the fuel injector return port until the end of the hose contacts the port flange (**A**, Figure 33).

NOTE: The fuel injector ports are labeled with arrows that indicated the direction of fuel flow. The arrow pointing toward the injector body indicates the fuel supply port, and the arrow pointing away from the injector body indicates the fuel return port.

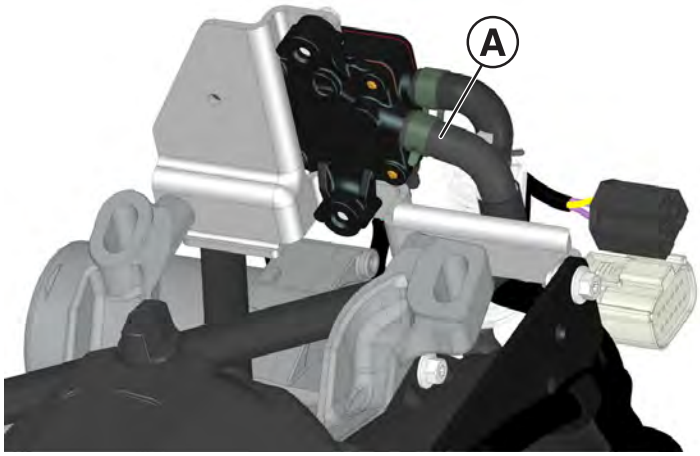
5. Squeeze the tangs of the fuel hose clamp and slide hose clamp over the injector port until it is **1/8 inch** (3 mm) from end of hose.
6. On engines equipped with remote fuel tanks, consult your equipment's repair manual for proper installation of the fuel return hose to fuel tank.
7. On engines equipped with a fuel tank, press the fuel return hose onto the fuel return port on the tank until the end of the hose contacts the port flange.
8. Squeeze the tangs of the fuel hose clamp and slide hose clamp over the tank port until it is **1/8 inch** (3 mm) from end of hose.
9. Install fuel tank. See *Fuel Tank - Installation*.
10. If removed, install air cleaner assembly. See *Air Cleaner Assembly - Installation*.
11. Install engine front cover panel. See *Front Cover Panel - Installation*.

Fuel Pump Pulse Hose - Removal

The fuel pump pulse hose runs between the crankcase port.

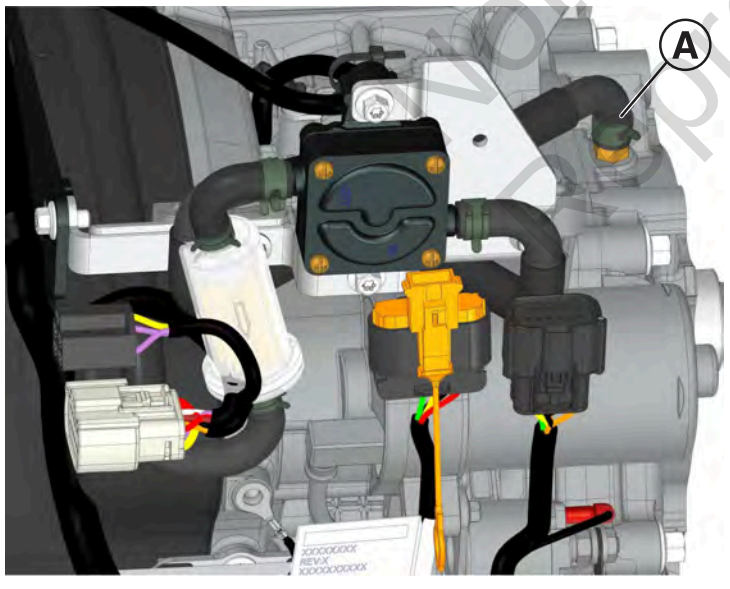
1. Remove engine side cover. See *Side Cover - Removal*.
2. Disconnect the pulse hose at the fuel pump (**A**, Figure 34). Squeeze the tangs of the clamp and slide the clamp along the hose away from the fuel pump. Using the fuel line removal tool, remove the pulse hose from the fuel pump port.

34



3. Disconnect the pulse hose at the crankcase port (**A**, Figure 35). Squeeze the tangs of the clamp and slide the clamp along the hose away from the crankcase port. Using the fuel line removal tool, remove the pulse hose from the port.

35



4. Feed the disconnected pulse hose underneath the fuel tank and toward the fuel pump until free from the engine. Inspect hose and replace as necessary.

Fuel Pump Pulse Hose - Installation

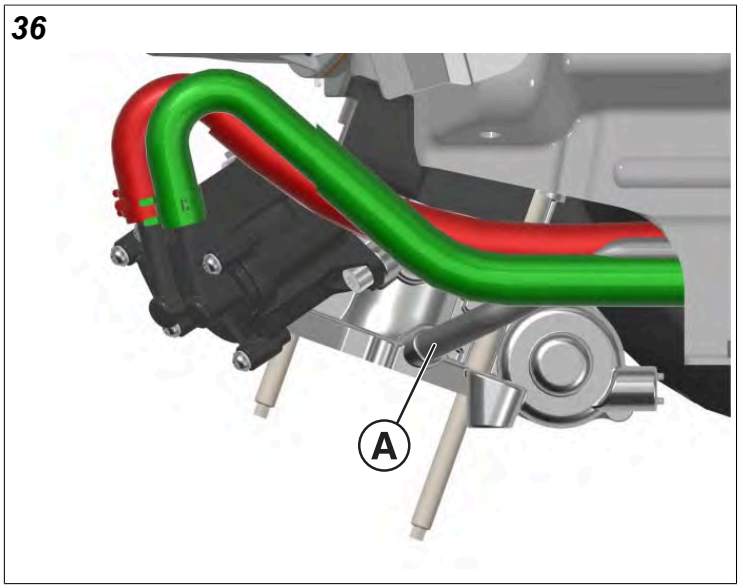
1. Feed the pulse hose underneath the fuel pump bracket and the fuel tank from the fuel pump side of the engine.
2. Connect end of the pulse hose to the crankcase port (**A**, Figure 35). Press the hose onto the port until the hose end contacts the port base.
3. Squeeze the tangs of the hose clamp and slide along the hose until the clamp is positioned above the crankcase port and **1/8 inch** (3mm) from the end of the hose.
4. Connect the end of the pulse hose to the fuel pump (**A**, Figure 34). Press the hose onto the fuel pump port until the hose end contacts the base of the port.
5. Squeeze the tangs of the hose clamp and slide along the hose until the clamp is positioned above the fuel pump port and **1/8 inch** (3mm) from the end of the hose.
6. Install the engine side cover. See *Side Cover - Installation*.

Fuel Vent Hose - Removal

Depending on your engine's trim, a fuel vent hose may be installed. The vent hose connects between the port on the ETC and the remote fuel tank. Engine's NOT equipped with a fuel vent hose will have the ETC port capped.

1. Remove front cover panel. See *Front Cover Panel - Removal*.
2. Depending on your engine's trim, it may be necessary to remove the air cleaner assembly to access the fuel vent hose. See *Air Cleaner Assembly - Removal*.
3. Disconnect the fuel vent hose from the ETC port (**A**, Figure 36). Using the fuel line removal tool, pull up on the hose to remove from the port.

36



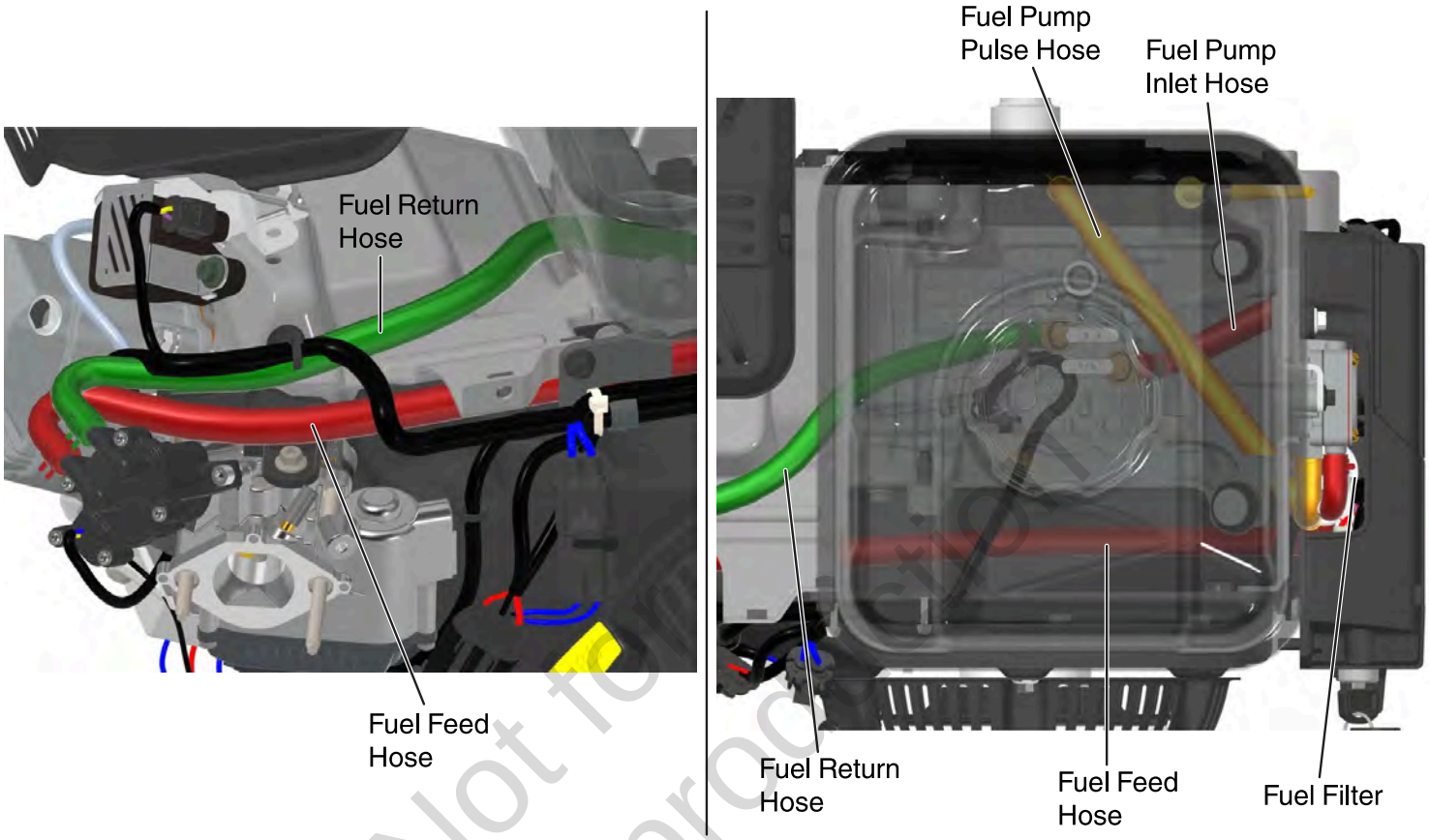
4. Disconnect the fuel vent hose from the remote fuel tank. See your equipment manual for the proper removal procedure.
5. Starting at the ETC port, feed the vent hose underneath the cylinder air guide and across the top of the blower housing.

6. Continue feeding the vent line out from the engine until free.

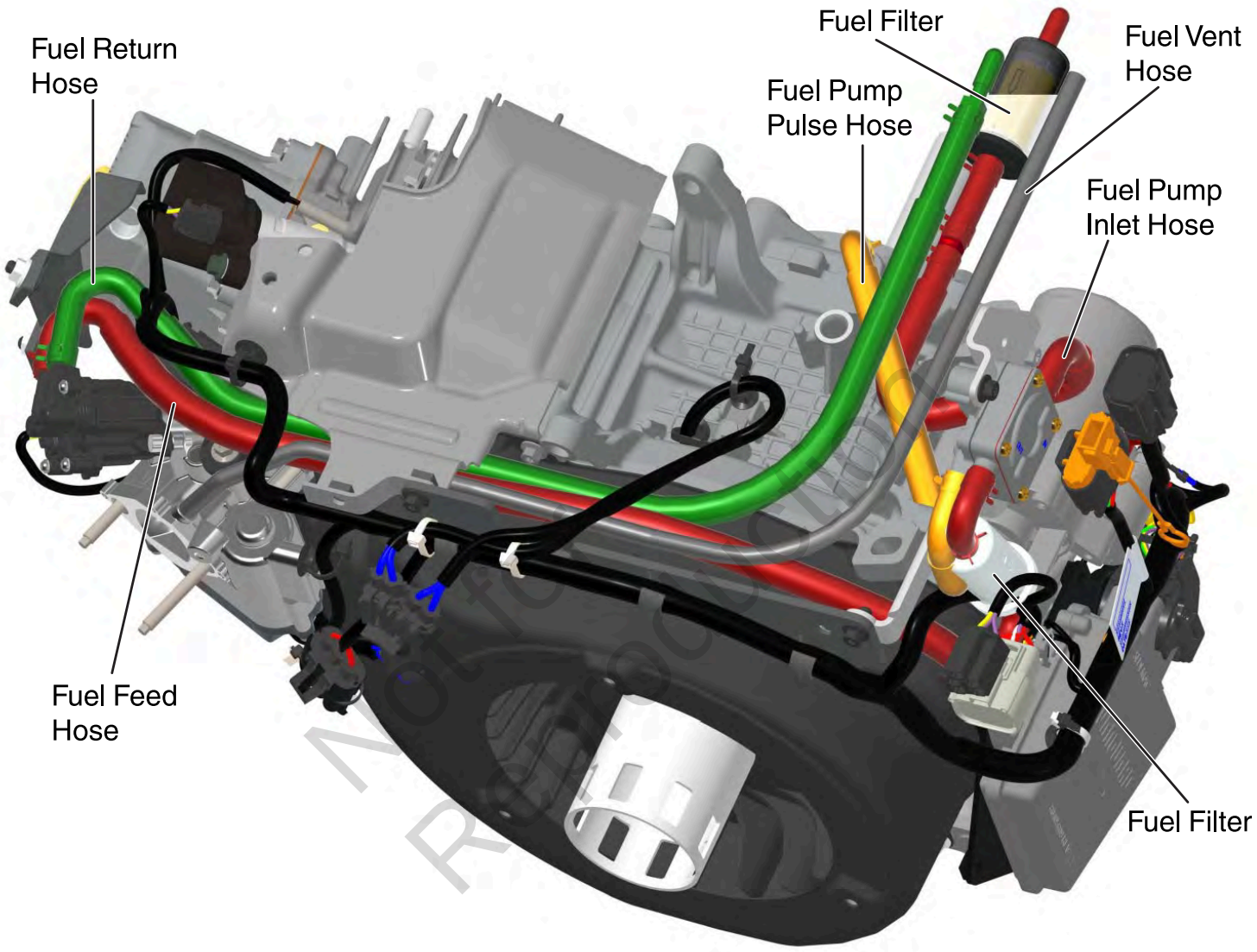
Fuel Vent Hose - Installation

1. Feed the fuel vent hose across the top of the engine and underneath the cylinder head air guide.
2. Continue to feed the vent hose underneath the engine wire harness until it reaches the vent port on the ETC assembly.
3. Press the vent hose onto the ETC port until the end of the hose contacts the port flange (**A**, Figure 36).
4. Connect the vent hose to the remote fuel tank. See equipment repair manual for proper procedure.
5. If removed, install the air cleaner assembly. See *Air Cleaner Assembly - Installation*.
6. Install engine front cover panel. See *Front Cover Panel - Installation*.

Model 25E300 Fuel Hose Location and Routing - With Tank



Model 25E300 Fuel Hose Location and Routing - Tankless



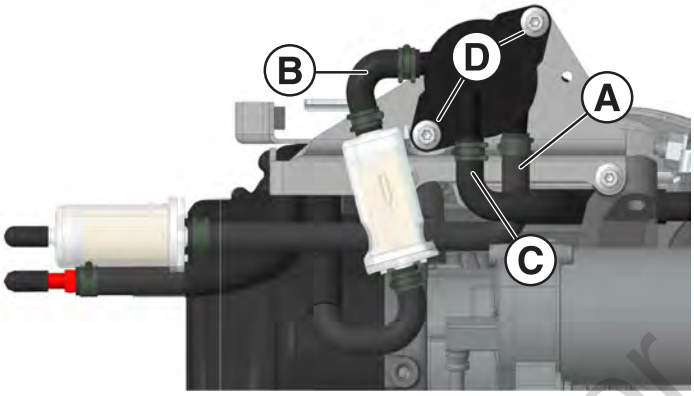
Mechanical Fuel Pump

Depending on your engine's trim, a Mikuni or Nikki fuel pump may be installed. The Mikuni fuel pump is characterized by a round body and the Nikki fuel pump has a square body. While the appearance my differ, the removal and installation procedures that follows applies to both, unless noted.

Mechanical Fuel Pump - Removal

1. See *Side Cover - Removal*.
2. Obtain a fuel line clamp. Install the clamp on the fuel supply hose (**A**, Figure 37) if equipped with a Mikuni fuel pump, and (**A**, Figure 38) if equipped with a Nikki fuel pump.

37



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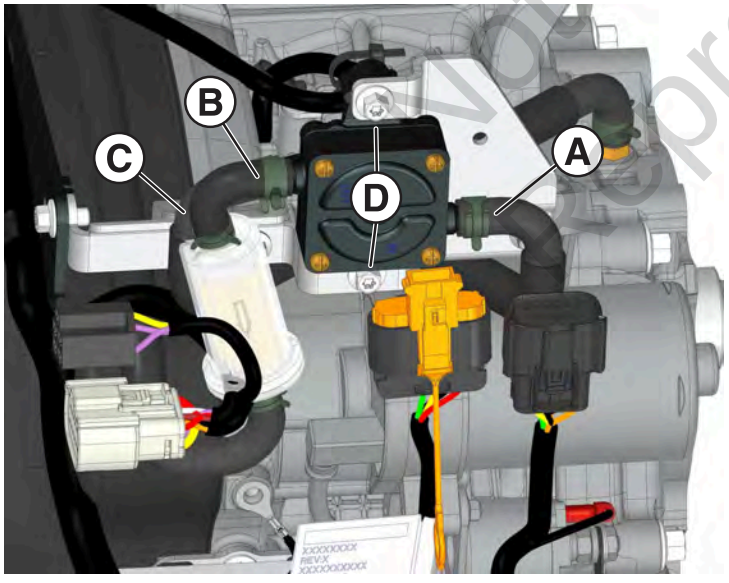


3. Squeeze the tangs and move the hose clamp away from the fuel inlet on the fuel pump.
4. Repeat step 2 for the fuel outlet hose (**B**) and pulse hose (**C**).
5. Remove the fuel inlet, fuel outlet and pulse hose from the fuel pump.

NOTE: Some residual fuel may be present in the fuel lines and pump. Wrap a rag or shop towel around the lines and pump to catch any spilled fuel. Make sure to clean and dispose of any spilled fuel in the proper receptacle.

6. Remove the two fasteners that secure the fuel pump to the mounting bracket (**D**). Remove the fuel pump from the bracket and set aside.

Mechanical Fuel Pump - Installation

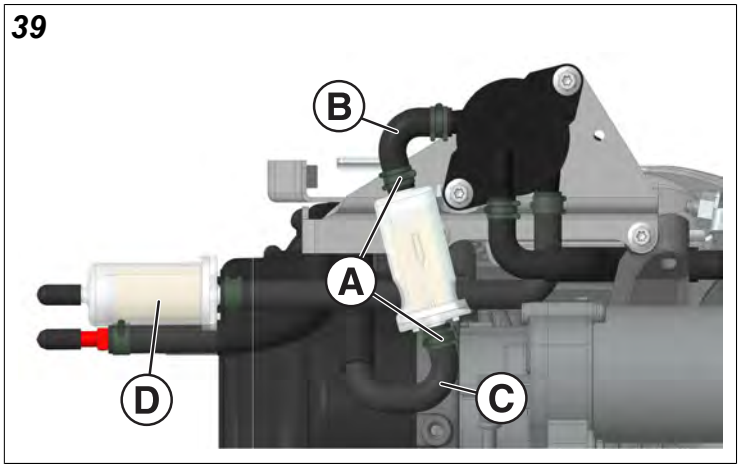
1. Install the fuel pump onto the mounting bracket.
2. Start by hand the two fuel pump fasteners (**D**, Figure 37 if equipped with Mikuni pump, and 38 if equipped with Nikki pump). Tighten to **95 lb-in** (10.7 Nm).
3. Install the fuel feed hose onto the fuel pump inlet port (**A**).
4. Install the fuel outlet hose (**B**) onto the fuel pump outlet port.
5. Install the pulse hose (**C**) onto the fuel pump pulse port.
6. Starting with the fuel feed line, squeeze the tangs of the fuel line clamp and slide the clamp along the hose until positioned above the port, **1/8 inch** (3 mm) from the end of the hose. Repeat for the fuel outlet hose and pulse hose.
7. Remove the fuel line clamp from the fuel feed hose.
8. Prior to installation of the side cover, check the fuel pump lines for leaks.

Fuel Filter

Fuel Filter - Removal

1. See *Side Cover - Removal*.
2. Squeeze tangs and move hose clamps (**A**, Figure 39) away from fuel inlet (**B**) and outlet (**C**) fittings.

39



3. Using a fuel line removal tool, remove fuel inlet and outlet hoses from fuel filter fittings.

NOTE: Depending on your engine's trim, a remote fuel tank may be equipped. In this instance a second fuel filter, between the fuel tank and the fuel pump, on the fuel supply hose (**D**, Figure 39) may be fitted. Follow steps 1-4 for removal of both fuel filters.

4. Discard **old** fuel filter in the appropriate receptacle.

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

Fuel Filter - Installation

1. With the arrow on the fuel filter (**A**, Figure 40) pointing in the direction of fuel flow, install **new** fuel filter between fuel inlet and outlet hoses.

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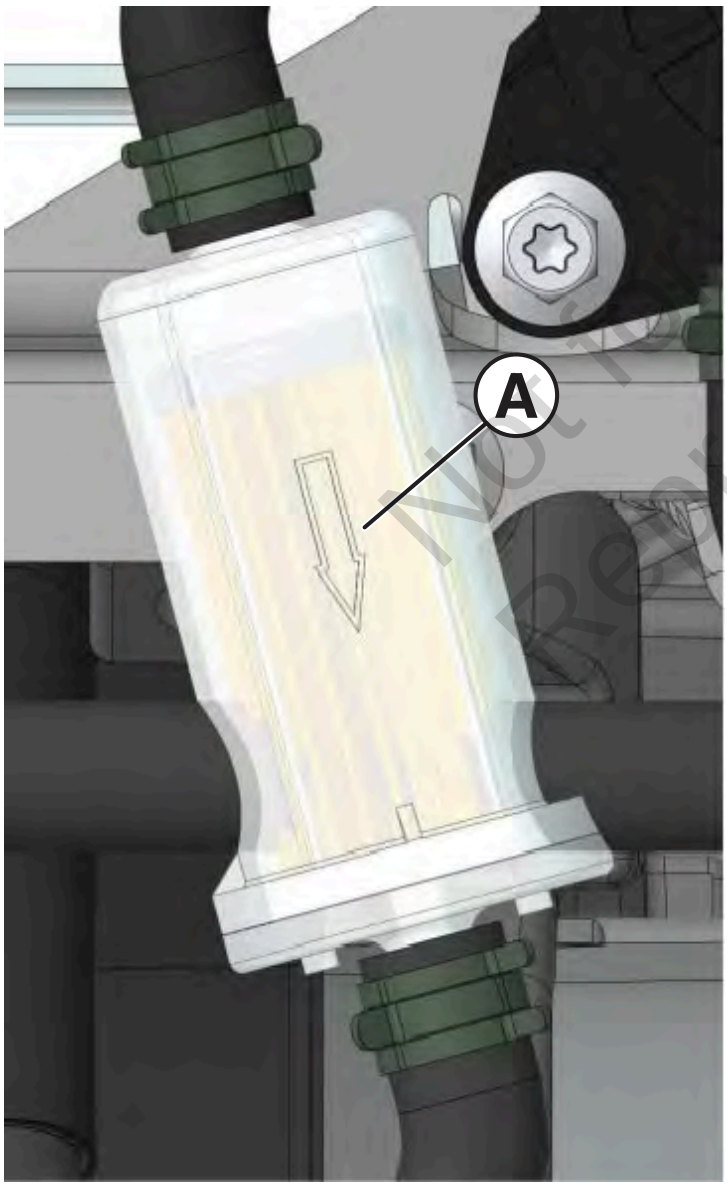


2. Press each fuel hose onto the fuel filter port until the end of the hose touches the port flange.

3. Squeeze the clamp tangs (**A**, Figure 39) and move each hose clamp until positioned above the fuel filter port and **1/8 inch** (3 mm) from end of each hose.

NOTE: Depending on your engine's trim, a remote fuel tank may be equipped. In this instance a second fuel filter, between the fuel tank and the fuel pump, on the fuel supply hose (**D**, Figure 39) may be fitted. Follow steps 1-4 for installation of both fuel filters.

4. Prior to installation of the side cover, check fuel filter hose connections for leaks.

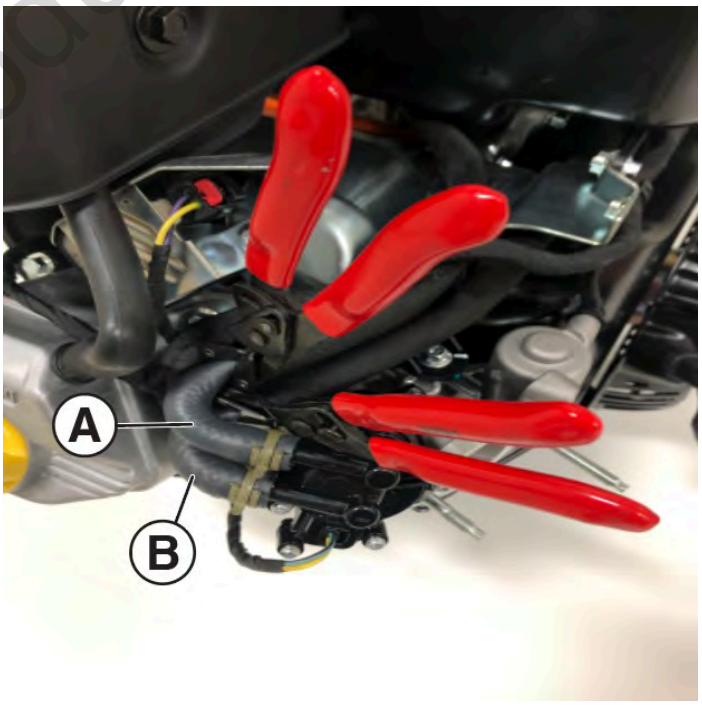
Fuel Injector

Fuel Injector - Removal

Before removal of the fuel injector, it is important to record the fuel line routing and orientation. The fuel injector has 2 fuel lines, a supply line and a return line. The ports on the fuel injector are stamped with arrows that identify the direction of fuel flow. Failure to install the fuel lines in the correct orientation will prevent the engine from operating properly.

1. See *Front Cover Panel - Removal* and *Air Cleaner Assembly - Removal*.
2. Install fuel line clamp on to the fuel return line (**A**, Figure 41).
3. Install fuel line clamp on to the fuel supply line (**B**).

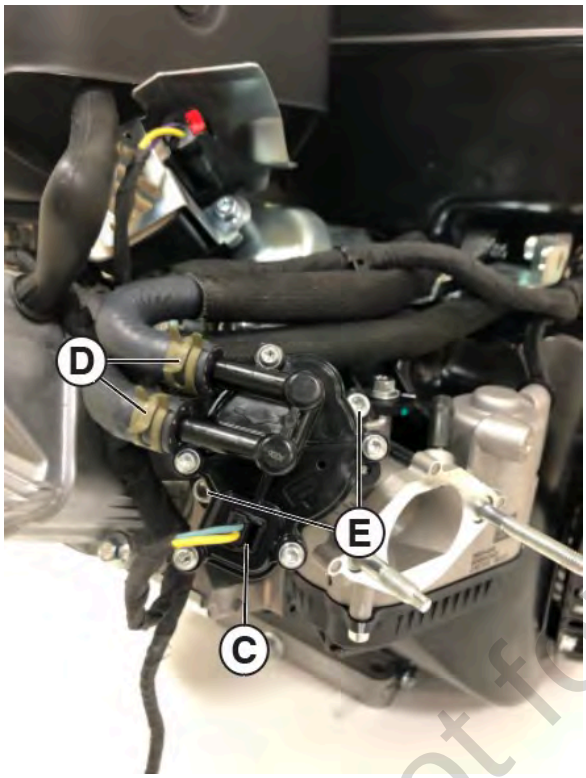
41



4. Disconnect the electrical connector at the fuel injector by depressing the tab and pulling the connector straight out (**C**, Figure 42).

5. Using a pliers, squeeze the fuel line clamp tabs (**D**) together and slide the clamps along the fuel line to allow for removal of the fuel lines. Repeat this step for both the supply and return fuel line.
6. Remove both fuel lines from the fuel injector by sliding the lines off of the fuel injector ports. A fuel line removal tool may be necessary for removal of the fuel lines.
7. Remove the two fuel injector fasteners (**E**).

42



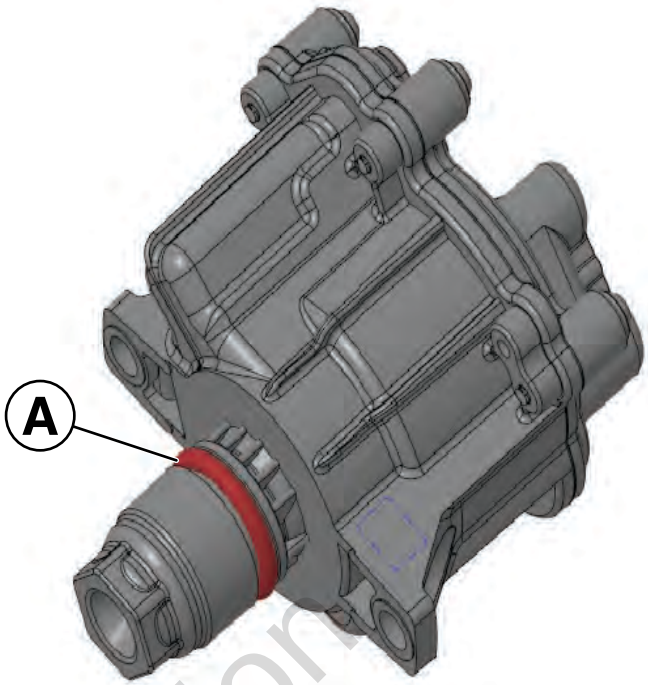
8. Remove the fuel injector from the throttle body housing by pulling the injector straight out.

Fuel Injector - Installation

Prior to installation of the fuel injector, make sure all mating surfaces are clean, dry and free from contamination.

1. Install fuel injector O-ring, if not already installed (**A**, Figure 43).

43



2. Lubricate the O-Ring with clean engine oil.
3. Install the fuel injector into the throttle body housing by pushing the injector into the housing until both mating surfaces meet. Rotate, if necessary, the injector so that the mounting bracket holes align with the mounting holes on the throttle body.

NOTE: Make sure the fuel injector is orientated in the correct direction. The two fuel line ports should face the engine valve cover.

4. Install the two fuel injector mounting bolts (**E**, Figure 42). Tighten to **13 lb-in**(1.5 Nm).
5. Install the two fuel lines on the fuel injector. Make sure that the supply and return lines are connected to the correct injector port, as indicated by arrows stamped on the injector.

NOTE: The fuel line that connects the fuel injector to the fuel pump is the supply line. The fuel line that connects the fuel injector to the fuel tank is the return line.

6. Install the two fuel line clamps by squeezing the tangs and sliding the clamps along the fuel line until they are in the correct position. Position the clamps **1/8 inch** (3 mm) from the end of the fuel lines (**D**).
7. Plug in the electrical connector to the fuel injector. The connector will "click" when fully installed (**C**).

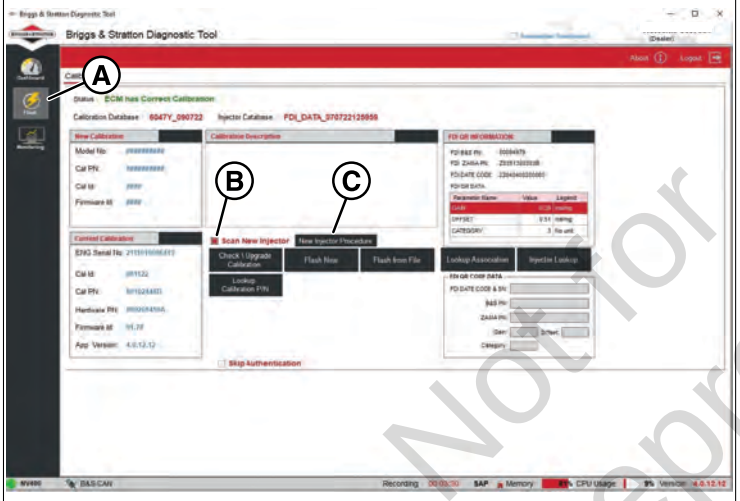
8. Remove the two fuel line clamps from the fuel feed and return lines.

NOTE: If replacing the fuel injector with new, you MUST update the fuel injector calibration. Proceed to *Update Fuel Injector Calibration* in this section.

Update Fuel Injector Calibration

1. See *SECTION 2 - DIAGNOSTIC INTRODUCTION - Using the Diagnostic Tool and Software*.
2. Click on the "Flash" icon (**A**, Figure 44) in the left menu of the Diagnostic Tool Software dashboard.
3. Click the "Scan New Injector" box (**B**) on the Flash dashboard.
4. Click the "New Injector Procedure" icon (**C**).

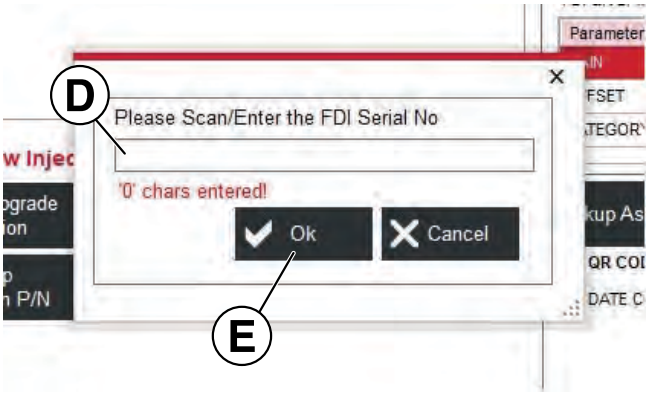
44



5. Enter the 14-digit fuel injector serial number in the text box (**D**, Figure 45) when the prompt appears.

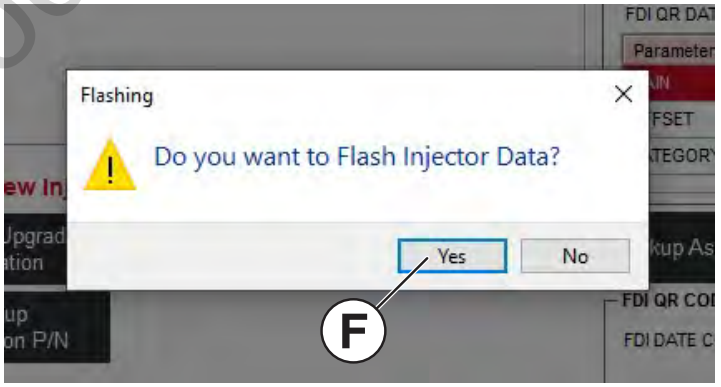
6. Click "Ok" (**E**) in the prompt box.

45



7. Click "Yes" (**F**, Figure 46) on the "Do you want to Flash Injector Data" prompt.

46



8. After the fuel injector data has been successfully flashed, a prompt will appear (**G**, Figure 47). Click "OK."

47

9. If the fuel injector data did NOT successfully update, repeat steps 2 through 7.

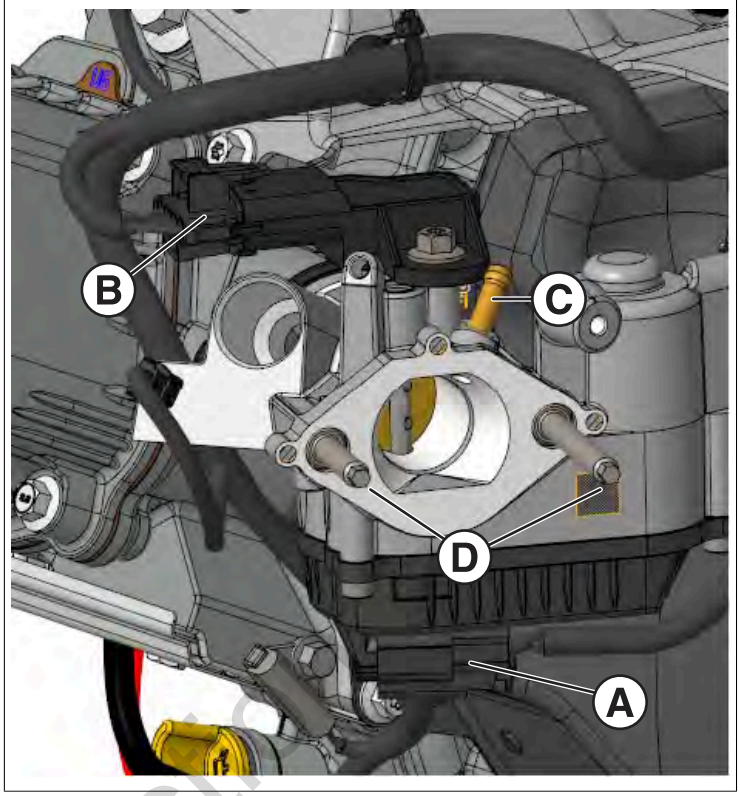
Electronic Throttle Control (ETC)

Electronic Throttle Control (ETC) - Removal

1. See *Front Cover Panel - Removal, Air Cleaner Assembly - Removal,* and *Fuel Injector - Removal*.

2. Disconnect the ETC electrical connector from the bottom of the throttle body housing (**A**, Figure 48).

48



3. Disconnect the ETC wire harness clip from the side of the throttle body housing. The cable clamp is a fir tree style push clip and can be removed easily with the Briggs & Stratton Fuel Line Removal Tool.
4. Disconnect the TMAP sensor electrical connector from the top of the throttle body housing (**B**). Pull out the red lock tab and then depress the release tab while pulling the connector free.
5. If equipped with fuel vent hose, disconnect the hose at the throttle body port (**C**).

NOTE: Engine without a fuel vent line will have a rubber cap installed on the throttle body vent port. Leave cap in place during disassembly.

6. Remove the two throttle body mounting studs (**D**).
7. Remove the throttle body, two gaskets and spacer from the engine. Discard **old** gaskets, retain the spacer, and set assembly aside.

Electronic Throttle Control (ETC) - Installation

1. Prior to assembly, make sure that all gasket, spacer and mating surfaces are clean, dry and free from contamination.

2. Sub-assemble the throttle body as follows:
   a. Insert the two throttle body mounting studs through the throttle assembly bores. From the air cleaner side of the throttle body, the SHORT stud mounts in the LEFT bore and the LONG stud mounts in the RIGHT bore.
   b. On the cylinder head side of the throttle body install the gasket and spacer stack.

NOTE: Using Figure 49 as a reference, install **new** gaskets and the retained spacer in the order and orientation as shown.

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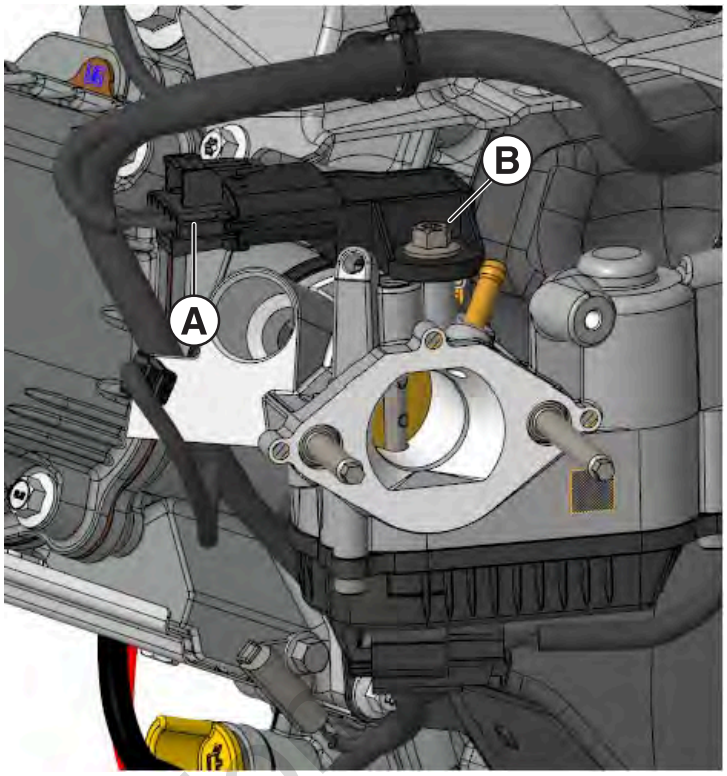
   c. Install the throttle body sub-assembly onto the cylinder head.
3. Start by hand the two throttle body mounting studs (**D**, Figure 48). Tighten to **80 lb-in** (9 Nm).
4. Attach the throttle harness cable clip to the mounting bore on the side of the throttle housing. Press the clip into the bore until the clip flange is flush with the throttle body.
5. Connect the throttle body wire harness electrical connector to the throttle body connector at the bottom of the throttle housing (**A**).
6. Connect the TMAP wire harness electrical connector to the TMAP sensor connector at the top of the throttle body (**B**).
7. If equipped, connect the fuel vent hose to the port on the throttle body (**C**).

TMAP Sensor - Removal

1. See *Front Cover Panel - Removal, Air Cleaner Assembly - Removal*.
2. Disconnect the TMAP sensor electrical connector from the top of the throttle body housing (**A**, Figure 50). Pull out the red lock tab and then depress the release tab while pulling the connector free.

50



3. Remove the TMAP sensor fastener (**B**).
4. Remove the TMAP sensor from the throttle body assembly by pulling the sensor vertically out of the sensor bore.

TMAP Sensor - Installation

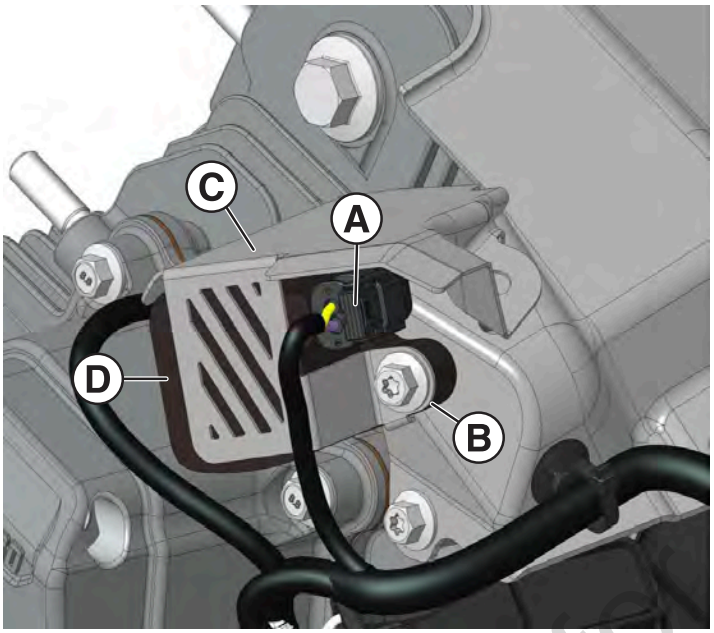
1. Make sure the TMAP sensor is clean, dry and free from debris and contamination.
2. Lubricate the sensor O-ring with clean engine oil.
3. Install the sensor into the throttle body assembly bore. Rotate to align the sensor mounting hole with the corresponding threaded hole on the throttle body.
4. Install the sensor fastener by hand (**B**, Figure 50). Tighten to **35 lb-in** (4 Nm).
5.
6. Connect the TMAP wire harness electrical connector to the TMAP sensor connector at the top of the throttle body (**A**).

Ignition Coil

Ignition Coil - Removal

1. Disconnect the ignition coil electrical connector (**A**, Figure 51) by first pulling up on the locking tab and then depressing the connector tab to release the connector.

51



2. Remove the upper ignition coil heat shield/air cleaner fastener (**A**, Figure 52).

52

3. Remove the lower ignition coil fastener (**B**, Figure 51).
4. Remove the ignition coil heat shield (**C**) and set aside.
5. Remove the ignition coil (**D**) from the spark plug by pulling the ignition coil and boot up and away from the spark plug. Set aside.

Ignition Coil - Installation

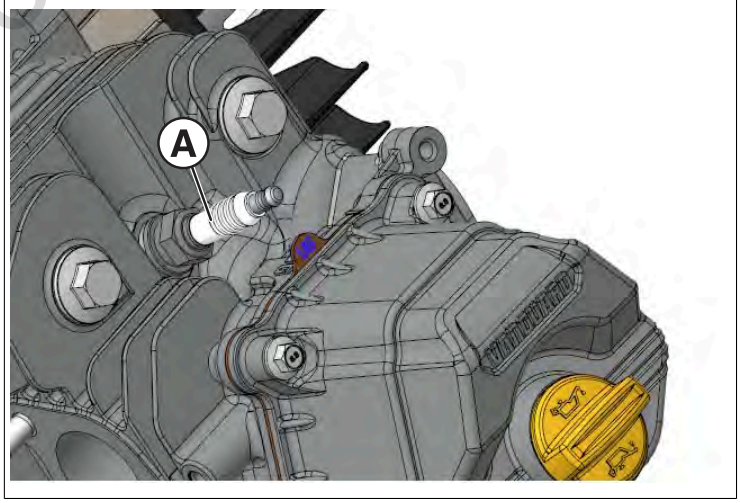
1. Install the ignition coil (**D**, Figure 51) onto the spark plug by pressing firmly until the boot is seated.
2. Install the ignition coil heat shield (**C**) on top of the ignition coil. Make sure the mounting holes align with the holes in the cylinder head.
3. Start by hand the lower ignition coil fastener (**B**). Tighten to **95 lb-in** (10.7 Nm).
4. Start by hand the upper ignition coil/air cleaner fastener (**A**, Figure 52). Tighten to **95 lb-in** (10.7 Nm).
5. Install the ignition coil electrical connector (**A**, Figure 51). Press the harness connector onto the ignition coil connector until it "clicks" into place. Press the locking tab down until fully seated.

Spark Plug

Spark Plug - Removal

1. See *Ignition Coil - Removal*.
2. Clean any dirt and debris that may have settled around the spark plug and spark plug bore. This prevents dirt and debris from falling into the cylinder.
3. Using a 5/8 inch spark plug socket, remove the spark plug (**A**, Figure 53) from the cylinder head bore.

53



4. Inspect the spark, replace as necessary.

Spark Plug - Installation

1. Make sure the spark plug threads and the cylinder head bore threads are clean and free from dirt and contamination.
2. Start by hand the spark plug (**A**, Figure 53) into the cylinder head bore. Turn the spark plug CLOCKWISE 3-4 turns to ensure correct thread engagement.

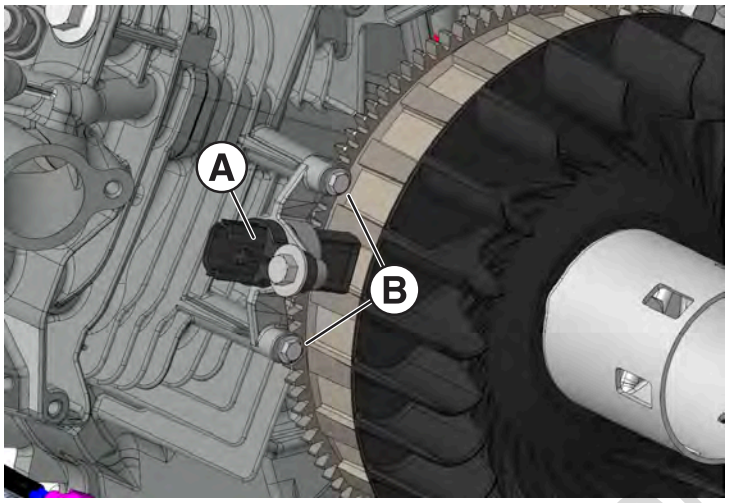
3. Using a 5/8 inch spark plug socket, tighten to **170 lb-in** (19.2 Nm).

Crankshaft Position Sensor (CKP)

Crankshaft Position Sensor - Removal

1. See *Front Cover Panel - Removal* and *Blower Housing - Removing*.
2. Disconnect the electrical connector from the crankshaft position sensor (**A**, Figure 54).

54

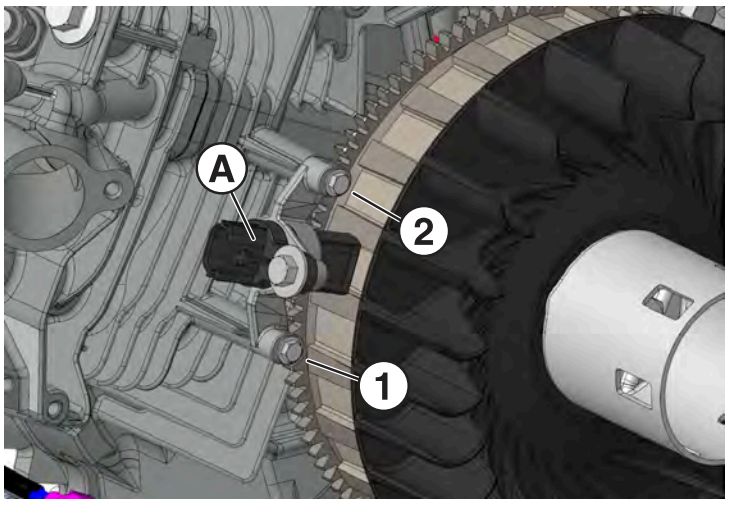


3. Remove the two crankshaft position sensor fasteners (**B**).
4. Remove the sensor from the engine bosses and set aside.

Crankshaft Position Sensor - Installation

1. Install the crank position sensor (**A**, Figure 55) onto the engine bosses.

55



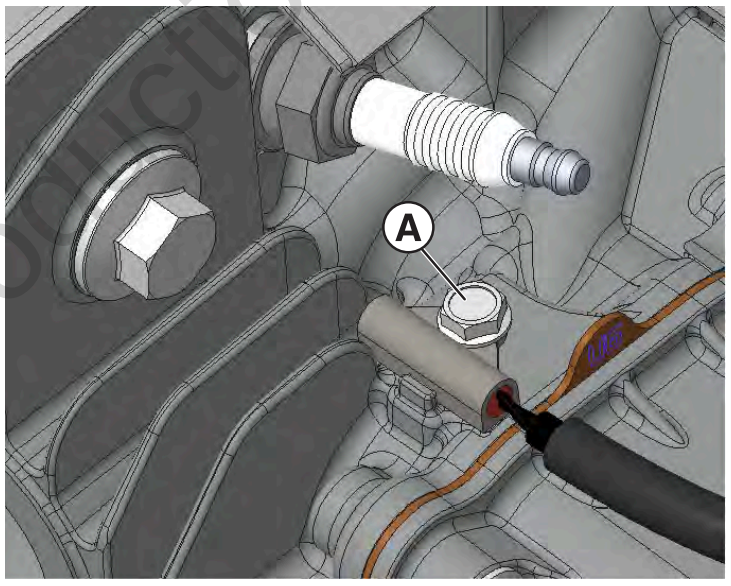
2. Start by hand the two crankshaft position sensor fasteners. Tighten until the fastener head makes contact with the sensor. DO NOT overtighten as the sensor air gap needs to be adjusted prior to final torqueing.
3. Using a feeler gauge, adjust the sensor air gap to **0.010-0.015 in** (0.25-0.38 mm).
4. While maintaining the specified sensor air gap, tighten the two sensor fasteners, in the sequence shown in Figure 55 to **28 lb-in** (3.2 Nm).
5. Connect the wire harness connector to the crankshaft position sensor electrical connector.

Engine Head Temperature Sensor (EHT)

Engine Head Temperature (EHT) Sensor - Removal

1. If equipped with high-mount air cleaner assembly, remove front cover panel and air cleaner assembly, see *Front Cover Panel - Removal* and *Air Cleaner Assembly - High Mount - Removal*.
2. Remove ignition coil, see *Ignition Coil - Removal*.
3. Remove the EHT sensor fastener (**A**, Figure 56).

56



4. Remove the sensor from the engine and set aside.

NOTE: The EHT is non-replaceable and does not disconnect from the engine harness. Replacement of the sensor requires wire harness replacement. See *Wire Harness - Removal* and *Installation* for replacement procedures.

Engine Head Temperature (EHT) Sensor - Installation

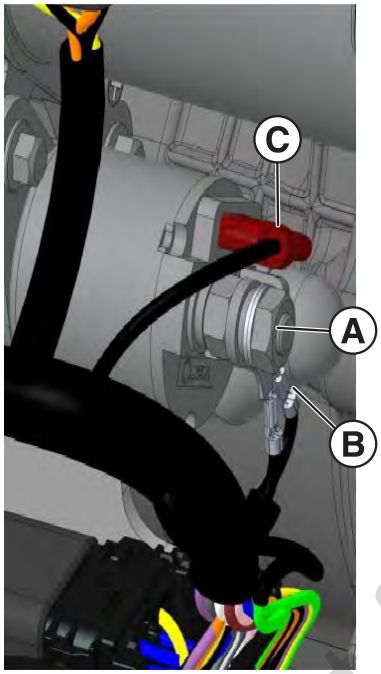
1. Install the EHT sensor onto the engine. Make sure that the sensor is touching the engine boss.
2. Start by hand the sensor fastener (**A**, Figure 56). Tighten to **45 lb-in** (5 Nm).

Wire Harness

Wire Harness - Removal

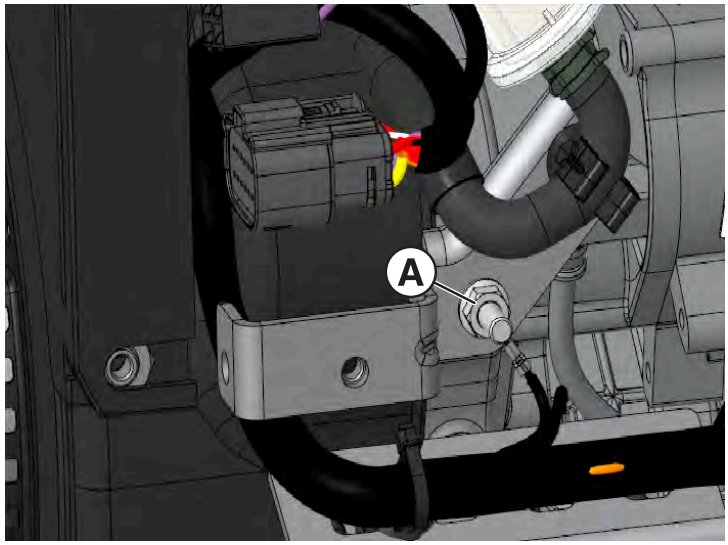
1. Starting on the starter motor side of the engine, remove the starter motor solenoid terminal nut, washer and lock washer (**A**, Figure 57). Remove the battery power and voltage regulator ring terminals from the starter motor solenoid post (**B**).

57



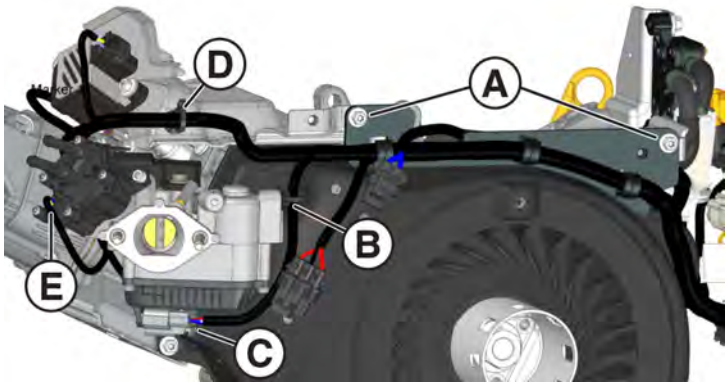
2. Disconnect the starter solenoid control circuit connector from the spade terminal (**C**).
3. Disconnect the oil level sensor connector.
4. Remove the three ECM shield fasteners, remove ECM shield from mounting bracket and set aside. See Figure in *Engine Control Module - Removal*.
5. Disconnect the ECM harness connector from the ECM by depressing the tab on the connector and picoting the latch down to release. See Figure in *Engine Control Module - Removal*.
6. Remove the ECM fastener that secures the ground ring terminal to the ECM. Remove ground ring terminal.
7. Remove the side cover electrical connector cover by releasing the snap tab and pivoting the cover away from the engine to remove. See Figure in *Side Cover - Removal*.
8. Release the diagnostic connector and equipment connector from the harness retaining tabs.
9. Remove the upper fastener on the operator panel. See Figure in *Operator Panel - Removal*.
10. Remove the lower side cover fastener to release the side cover from the mounting bracket. Remove side cover from engine and set aside.
11. Remove the fastener securing the battery ground ring terminal to the side cover lower mounting bracket (**A**, Figure 58). Remove ground ring terminal from fastener.

58



12. Remove the two operator panel to front cover panel fasteners. See Figure in *Operator Panel - Removal*.
13. Disconnect the key switch electrical connector from the key switch.
14. If equipped, disconnect the operator panel connector by pulling out the red locking tab and then removing the connector from the panel. Set operator panel aside.
15. At the front of the engine, remove the three front cover panel fasteners. Remove front cover panel from engine and set aside. See Figure in *Front Cover Panel - Removal*.
16. Remove air cleaner assembly, see *Air Cleaner Assembly - Removal*.
17. Remove the two wire harness guide fasteners (**A**, Figure 59) from the mounting bracket.

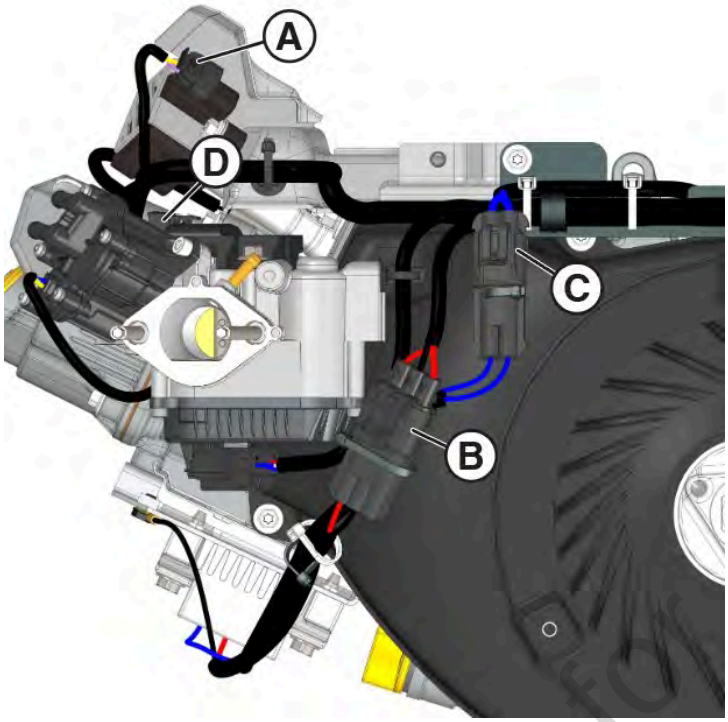
59



18. Remove the fir tree style cable clip (**B**) from the side of the electronic throttle control (ETC).
19. Disconnect the ETC harness connector (**C**) by pulling out the red lock tab and then depressing the connector tab while pulling to release.

20. Remove the fir tree style cable clip (**D**) from the cylinder head air guide.
21. Disconnect the fuel injector electrical connector (**E**) by pulling out the red lock tab and then depressing the release tab while pulling the connector free.
22. Disconnect the ignition coil electrical connector (**A**, Figure 60).

60



23. Disconnect the 3-place voltage regulator electrical connector (**B**).
24. Disconnect the 2-place voltage regulator electrical connector (**C**).

NOTE: The voltage regulator electrical connectors may be secured to the blower housing with tie wraps. You must cut the tie wrap to remove the connectors from the housing. Make sure you do not damage or cut the electrical connector or wiring when removing tie wraps.

25. Disconnect the TMAP sensor electrical connector from the top of the ETC (**D**). Pull out the red lock tab and then depress the release tab while pulling the connector free.
26. Remove the ETC from the cylinder head, see *Electronic Throttle Control (ETC) - Removal*.
27. Remove blower housing, see *Blower Housing - Removal*.
28. Disconnect the crank position sensor electrical connector from the sensor. See *Crankshaft Position Sensor (CKP) - Removal*.
29. Remove the ignition coil, see *Ignition Coil - Removal*.
30. Remove the engine head temperature sensor (EHT), see *Engine Head Temperature Sensor (EHT) - Removal*.
31. Remove the wire harness from the engine and set aside.

Wire Harness - Installation

1. Starting at the cylinder head side of the engine, install the EHT sensor and fastener. See *Engine Head Temperature Sensor (EHT) - Installation*.
2. Install the ignition coil. See *Ignition Coil - Installation*.
3. Connect the ignition coil harness connector to the coil. Press connector until it "clicks" into place.
4. Connect the CKP sensor harness connector to the sensor. Press connector until it "clicks" into place.
5. Install blower housing. See *Blower Housing - Installation*.
6. Install the ETC onto the cylinder head. See *Electronic Throttle Control (ETC)*.
7. Connect the TMAP harness connector to the sensor (**D**, Figure 60). Press connector until it "clicks" into place then press the red locking tab until secure.
8. Connect the fuel injector harness connector to the injector (**E**, Figure 59). Press connector until it "clicks" into place.
9. Connect the ETC harness connector to the bottom of the ETC (**C**, Figure 59). Press connector until it "clicks" into place then press the red locking tab until secure.
10. Connect the voltage regulator harness connectors to the regulator connectors (**B and C**, Figure 60). Press connectors together until they "click" into place.
11. Connect the ETC fir tree style cable clip onto the ETC (**B**, Figure 59). Press the clip into the bore until the clip flange is flush with the ETC body.
12. Connect the cylinder head fir tree style clip onto the cylinder head air guide (**D**, Figure 59). Press the clip into the bore until the clip flange is flush with the air guide body.
13. Lay the engine wire harness on top of the blower housing. Install the harness mounting plate to the engine mounting bracket. Start by hand the two mounting plate fasteners (**A**, Figure 59). Tighten to **60 lb-in** (6.8 Nm).
14. Install the air cleaner assembly. See *Air Cleaner Assembly - Installation*.
15. Install the front cover panel. See *Front Cover Panel - Installation*.
16. Connect the key switch harness connector to the key switch terminal on the operator panel.
17. If equipped, connect the operator panel harness connector to the switch connector. Press the connector onto the switch terminal until it "clicks" into place then press the red locking tab until secure.
18. Install the operator panel onto the engine. See *Operator Panel - Installation*.
19. Install the battery ground ring terminal to the ground stud. Tighten to **95 lb-in** (10.7 Nm).
20. Install side cover. See *Side Cover - Installation*.
21. Install ECM. See *Engine Control Module - Installation*.

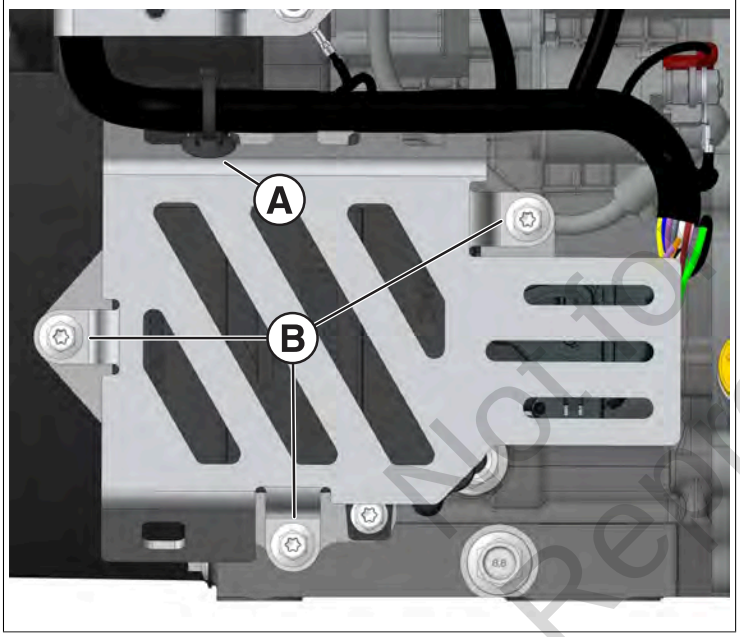
22. Connect the oil level sensor harness terminal to the sensor terminal. Press both terminal together until fully seated.
23. Connect the starter solenoid control circuit harness connector to the spade terminal on the solenoid (**C**, Figure 57).
24. Install the flat washer and lock washer followed by the battery power and voltage regulator ring terminals onto the starter motor solenoid post (**B**, Figure 57).
25. Install the starter solenoid post terminal nut (**A**, Figure 57). Tighten to **35 lb-in** (4 Nm).

Engine Control Module (ECM)

Engine Control Module (ECM) - Removal

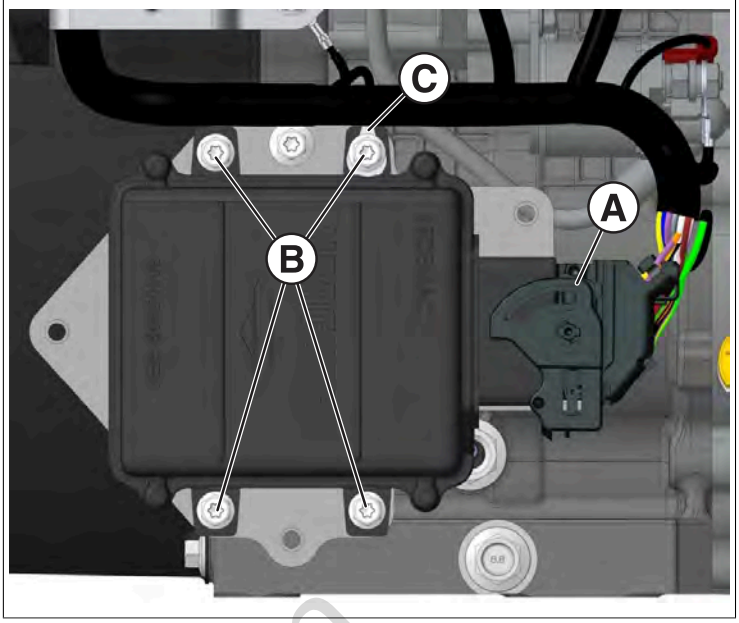
1. Remove the fir tree style wire clamp from the ECM shield (**A**, Figure 61).

61



2. Remove the three ECM shield fasteners (**B**). Remove the shield from the mounting bracket and set aside.
3. Disconnect the ECM harness connector by depressing the tab and then pivoting the latch down (**A**, Figure 62) to release the connector.

62



4. Remove the four ECM fasteners (**B**.

NOTE: A ring terminal from the main engine harness is mounted behind the upper right (**C**) ECM fastener.

5. Remove the ECM from the mounting bracket and set aside.

Engine Control Module - Installation

1. Align the ECM with the mounting holes on the ECM bracket. The ECM connector must face toward the PTO side (rear) of the engine.
2. Start by hand the four ECM fasteners (**B**, Figure 62). Make sure that the main engine harness ground ring terminal (**C**) is installed behind the upper right ECM mounting fastener. Tighten to **95 lb-in** (10.7 Nm).
3. Install the ECM harness connector (**A**) onto the ECM. Press the connector onto the ECM and pivot the latch up until it "clicks" into place and is secure.
4. Install the ECM shield onto the ECM bracket.
5. Start by hand the three shield fasteners (**B**, Figure 61). Tighten to **95 lb-in** (10.7 Nm).

6. Install the fir tree style harness clip (**A**) into the ECM shield hole by pressing the clip into place until the flange is flush with the shield.

NOTE: If replacing the ECM with new, you MUST connect to the diagnostic tool software and update the ECM and fuel injector calibration. Failure to update the new ECM with the most current calibration and the fuel injector calibration may cause engine performance issues.
See the diagnostic tool manual for ECM calibration update procedures. See *SECTION 6 - REMOVAL AND INSTALLATION - Fuel Injector - Update Fuel Injector Calibration*.

SECTION 7 - SPECIFICATIONS

Engine Specifications

ENGINE - 25E300	
Bore	3.465 in (88 mm)
Stroke	2.638 in (67 mm)
Displacement	24.898 ci (408 cc)
Compression Ratio	8.4:1
Crankshaft End Play	0.010-0.019 in (0.25-0.48 mm)
Crankshaft End Play (Pump Applications)	0.005-0.120 in (0.12-0.3 mm)
Oil Capacity	28-32 oz (830-950 ml)
Fuel Tank Capacity	6.4 qt (6.1 L)
Ignition Timing	Variable
Crank Position Sensor (CKP) Air Gap	0.010-0.015 in (0.25-0.38 mm)
Spark Plug Gap	0.030 in (0.76 mm)
Valve Clearance - Intake	0.004-0.006 in (0.10-0.15 mm) @ TDC of compression stroke
Valve Clearance - Exhaust	0.006-0.008 in (0.15-0.20 mm) @ TDC of compression stroke
Crankcase MAG Bearing Oil Seal Depth	0.049-0.069 in (1.25-1.75 mm)
Crankcase PTO Bearing Oil Seal Depth	0.177-0.197 in (4.5-5.0 mm)

Torque Specifications

Fastener	Torque
Air Cleaner to Throttle Body	40 lb-in (4.5 Nm)
Air Cleaner Upper Fastener/Ignition Coil Heat Shield	95 lb-in (10.7 Nm)
Air Cleaner Lower Support Bracket to Engine Block - Low Mount	95 lb-in (10.7 Nm)
Air Cleaner Lower Rear Support - Low-Mount	50 lb-in (5.6 Nm)
Blower Housing to Engine Block	96 lb-in (10.7 Nm)
Crankshaft Position Sensor (CKP) to Engine Block	28 lb-in (3.2 Nm)
Engine Control Module (ECM) to Mounting Bracket	95 lb-in (10.7 Nm)
Engine Control Module (ECM) Shield to Mounting Bracket	95 lb-in (10.7 Nm)
Engine Head Temperature Sensor (EHT) to Cylinder Head	45 lb-in (5 Nm)
Front Cover Panel to Throttle Body Stud	30 lb-in (3.4 Nm)
Front Cover Panel to Engine Block	50 lb-in (5.6 Nm)
Front Cover Panel Upper Fastener - Low Mount or Remote Air Cleaner	50 lb-in (5.6 Nm)
Fuel Injector to Throttle Body	13 lb-in (1.5 Nm)
Fuel Tank - Front of Engine Fastener	160 lb-in (18 Nm)
Fuel Tank - Rear of Engine Fastener	160 lb-in (18 Nm)
Fuel Tank - Side of Engine Fasteners	160 lb-in (18 Nm)
Ignition Coil to Cylinder Head	95 lb-in (10.7 Nm)
Mechanical Fuel Pump to Mounting Bracket	95 lb-in (10.7 Nm)
Operator Panel to Front Cover Panel	50 lb-in (5.6 Nm)
Operator Panel to Side Cover	50 lb-in (5.6 Nm)
Rewind Starter to Blower Housing	30 lb-in (3.4 Nm)
Side Cover to Mounting Bracket	50 lb-in (5.6 Nm)
Spark Plug	170 lb-in (19.2 Nm)
Starter Motor Solenoid Post Terminal Nut	35 lb-In (4 Nm)
Throttle Body Mounting Stud	80 lb-in (9 Nm)
TMAP Sensor Fastener	35 lb-in (4 Nm)
Wire Harness Mounting Plate to Engine Block	60 lb-in (6.8 Nm)
Wire Harness Ground Terminal to Side Cover Bracket	95 lb-in (10.7 Nm)

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