ROUSH CLEANTECH

Ford E-350 / E-450

Gen 4 Propane

Service Manual

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FOREWARD

This manual is intended to provide technicians with the procedures required to maintain and service the unique components of the ROUSH CleanTech Liquid Propane Autogas (LPA) system. Service procedures for other vehicle components may be referenced to, which can be found in the Ford Workshop Manual or Ford Powertrain/Emissions Diagnosis Service Manual. For access to the Ford manuals, please subscribe to www.motorcraft.com.

⚠ WARNING

Technicians working with, or around, fuel systems should be properly trained to utilize extreme care and caution at all times. Failure to exercise extreme caution and care may lead to serious accidents which can result in property damage, personal injury and/or death.

INTRODUCTION

LPA System Overview

This manual is a supplement to the regular Ford Workshop Manual, covering the unique components of the ROUSH CleanTech Liquid Propane Autogas (LPA) fuel system. Unlike the traditional propane-powered vehicle that supplies propane to the engine in a vapor form, the LPA system delivers, meters, and injects liquid propane into the engine.

Similar to a modern gasoline engine, the LPA system stores liquid propane in the fuel tank. Dual in-tank electric fuel pumps circulate the propane through fuel rails which supply fuel to the fuel injectors. The injectors meter and inject liquid propane into each of the original inlet ports on the Ford engine. Fuel that is not used by the injectors will return to the fuel tank through a flow control solenoid.

The ROUSH CleanTech LPA system is fully integrated using Ford's one touch integrated start (OTIS) system. When the ignition key is turned to START and released to the ON position, the LPA system runs a purge process, then the starter engages and the vehicle starts with no further action required from the operator.

Fueling a propane-powered vehicle is noticeably different than on a conventional fueled vehicle. A propane fuel system is completely sealed and the major difference is the fill nozzle. There are 2 types of fill nozzles and valves used for propane: a screw-on type and a quick-connect type (also known as "euro style"). When fueling with the screw-on type, turn connector clockwise to tighten, ensuring a good seal at the fill valve. With the quick-connect type, fully engage the nozzle to the valve, ensuring a good seal at the fill valve. The tank is equipped with an Overflow Protection Device (OPD), which only allows to tank to be filled to 80% of the overall tank volume, leaving room for the fuel to expand. At the 80% fill level, the dash fuel gauge will read full. The filling times should be comparable to that of gasoline or diesel but things such as ambient temperature and filling station pressure settings can affect these filling times.

Liquid propane autogas is also called liquid (or liquefied) petroleum gas (LPG, sometimes just LP gas). A vapor at normal room temperature and atmospheric pressure, a moderate increase in pressure produces its liquid state at ambient temperatures. It vaporizes readily when released. Because the liquid contains so much more energy than the same volume of vapor, liquid propane autogas is stored and shipped under pressure.

Maintenance

Ford vehicles equipped with the ROUSH CleanTech Propane fuel system should follow all engine, transmission, and body maintenance outlined in the Ford owner's manual. Alternate maintenance schedules or fluids are not recommended.

For the propane fuel system, there is a Fill Filter and In-Line Supply Filter that both need to be replaced every 50,000 miles. Refer to the replacement procedures in this manual.

ROUSH CleanTech Technical Assistance

Call ROUSH CleanTech Customer Service at 800.59.ROUSH (597-6874) with any questions regarding ROUSH CleanTech Liquid Propane Autogas systems.

Propane

Propane exists as a gas in its natural state, and like diesel fuel, gasoline, or natural gas, is a member of the hydrocarbon family. Propane is a by-product of refined petroleum and natural gas. When stored under pressure, the propane turns into a liquid. Propane is colorless, odorless, and non-toxic. Ethyl mercaptan is added to propane during the manufacturing process to give it a distinct, recognizable odor.

Propane is commonly referred to as LPG or LP gas. Like most liquids, liquid propane expands as its temperature increases. This is why propane tanks are only filled to 80% of its water capacity. Even with an 80% fill capacity, due to liquid propane's expansion ratio of 1:270 (liquid propane to a gas by volume) and its high BTU rating, a large volume of energy can be stored in a relative small tank under relative low pressure.

Propane also has a very narrow range of flammability with a 2.2% threshold on the low side and a 9.6% threshold on the high side. This means that if the propane-to-oxygen mixture is lower than 2.2% or higher than 9.6%, the mixture is noncombustible.

Propane is heavier than air; therefore, a leak in a propane fuel system can result in a gas accumulation in low places, such as sewers, drains, or service pits. This can create a fire and health hazard as the propane will displace oxygen, potentially resulting in suffocation. For this reason, additional safety precautions should be observed when working on or around propane-powered equipment or storage tanks.

Propane is stored in the vehicle fuel tank under pressure as a liquid. The pressure in the tank is determined by the temperature of the fuel, ranging from 0 psi at minus 44°F, to 375 psi at 161°F. The tank has a pressure relief valve (PRV) which vents the tank at pressures over 312 psi or 375 psi, depending on the application.

ROUSH CleanTech LPA vehicles require HD-5 propane, rated for automotive use. Use of HD-10 or other substandard propane may result in excess contamination of the system and premature failure of the fuel pump, injectors and in-tank filter.

Propane, like other fuels, must be handled safely with knowledge of its characteristics. Training in propane characteristics and handling is available through the Propane Education and Research Council (PERC), 1140 Connecticut Avenue, Washington, DC 20036. Their web address is www.propanecouncil.org.

Fill Stations

Propane is readily available anywhere in the United States. To locate the nearest station, check with www.afdc.energy.gov/afdc/locator/stations.

ROUSH CleanTech recommends facilities designed for automotive refueling. Other locations may have low-output pumps, resulting in slow or no fill, or low-quality fuel which can result in premature component failure.

⚠ WARNING

Service and System Modification

CleanTech does not approve of any additions to or modifications of this fuel system. This fuel system is designed and installed to meet federal standards and engine manufacturer's guidelines. The maintenance provider or modifier assumes all responsibility for the vehicle engine and fuel system if the fuel system is changed or modified. Some states require a special license to perform maintenance or work on propane-powered vehicles. Check with local authorities or your state LP Gas Association for details. All fuel system components must be a minimum of 18 inches from any exhaust system component unless properly shielded. All service, maintenance and repairs performed on LP Gas systems must be done by an authorized LP Gas service technician.

SAFETY INFORMATION

The National Fire Protection Association (NFPA) publishes a code book of rules that apply to the storage, handling, transportation, and use of liquefied petroleum gas (LP-Gas or LPG). The book is known as NFPA 58. It is revised as necessary and published every other year. This code is adopted as law in virtually every political subdivision in the United States. Check with your local authorities for regulations applicable to liquid propane.

Alert Messages

The following alert messages appear from time to time in the appropriate places in this manual. Ensure that all personnel in the immediate area are aware of these reminders. Although propane is nontoxic, nonpoisonous, has the lowest flammability range of any alternative fuel, and dissipates quickly when released into the atmosphere, extreme care must be taken when working with the fuel and fuel system.

⚠ DANGER

Leaked or vented propane will expand quickly when no longer pressurizing in the fuel system. Liquid propane expands at a ratio of 1:270 going from a liquid to vapor. Propane vapor is heavier than air and seeks the lowest point. When the ratio of propane to air is between 2.2% and 9.6%, propane will burn in the presence of an ignition source at 940°F (504°C) or hotter. Keep away from

heat, sparks, flames, static electricity, lighted smoking materials, or other sources of ignition. Failure to heed this danger may result in severe personal injury or death.

⚠ DANGER

Fuel lines remain pressurized after engine shutdown. Keep away from heat, sparks, flames, static electricity, or other sources of ignition. Do NOT enter storage areas or confined space unless they are adequately ventilated. Failure to heed this danger may result in severe personal injury or death.

⚠ DANGER

Liquid propane is cold. When liquid propane is released from a pressurized vessel, it rapidly evaporates, creating a refrigeration effect that can cause frostbite. Wear non-porous, cold-safe gloves, eye protection, and ear protection during venting and repair operations. Keep moisture away from the valves. Failure to heed this warning can result in personal injury.

⚠ DANGER

Always follow all NFPA 58 guidelines. When working on the propane fuel system or refueling a vehicle, you must be in a well-ventilated area at least 25 ft from any ignition source and 35 ft from any activity that throws sparks. Failure to heed this danger may result in severe personal injury or death.

⚠ WARNING

Technicians working with, or around, fuel systems should be properly trained to utilize extreme care and caution at all times. Failure to exercise extreme caution and care may lead to serious accidents which can result in property damage, personal injury, and/or death.

Installation, Garaging, and Training

Chapter 11 of NFPA 58 applies to engine fuel systems using LP-Gas in internal combustion engines, including containers, container appurtenances, carburetion equipment, piping, hose and fittings and their installation. Additionally, this chapter applies to garaging of vehicles and to the training of personnel.

Paragraph 11.2 specifies that each person engaged in installing, repairing, filling, or otherwise servicing an LP-Gas engine fuel system shall be trained. Contact the Propane Education and Research Council to learn more about their CETP E-Learning computer-based training program

Purging and Venting (Tanks and Lines)

Venting of LP-Gas to the atmosphere is covered by paragraphs 7.3.1, General, and 7.3.2, Purging of NFPA 58, 2008 edition. Refer to NFPA 58, Local Codes and Proper Training for specific information relating to safe venting of LPG.

VEHICLE INFORMATION

Build Data

ROUSH CleanTech emissions certification information is recorded on the ROUSH CleanTech vehicle emissions control information (VECI) label. The label is vehicle-specific and is required by law to be on the vehicle to which it is assigned, along with the Ford VECI label. This ensures that sufficient expansion volume is present in case of significant tank temperature changes.

Start Sequence

When the engine is not running, the fuel in the rails boils and turns to vapor. For proper engine operation, the vapor must be flushed from the rails prior to starting the engine. This is a fully automated process that is controlled by the PCM. This process typically takes 2-15 seconds, depending on ambient conditions, engine off time, and engine temperature at shutdown. Maximum flush time before the engine cranks is 180 seconds.

The cycle will begin when the operator turns the key to the START position and releases the key to the ON position. After receiving the start request, the PCM initiates the start sequence. During this time, the PCM performs diagnostics on several of the solenoids, as well as flushes the vapor from the rails. This is accomplished by monitoring the integrated pressure temperature sensor (IPTS) while opening the various solenoids in the tank and FRPCM in stages, then engaging the fuel pumps. Refer to *LPA Fuel System Components and Function* for a more detailed description of the components.

Stage	Name	Description
1	CAN Bus Initialization	For the sequence to work, the PCM and Gateway Module need to be communicating. There is a short delay after key-up to ensure communication has been established.
2	Bleed Diagnostic Pressure Read	The PCM measures the fuel pressure in the rail after a bleed cycle. All solenoids are still closed at this time. If the pressure is too high, the system did not bleed and a fault will set.
3	Open Tank Solenoid	The tank solenoid is energized. The pressure in the rail is measured (again). This pressure will used later to determine if the FRPCM supply solenoid has properly opened.
4	Open Supply Solenoid	The FRPCM supply solenoid is energized.
5	Flush	The flow control solenoid (FCS) is energized and the fuel pump is turned on high speed. The IPTS monitors pressure and temperature in the rail to determine when the vapor has been cleared from the rail.
6	Pressure Build	The FCS is de-energized and the pressure is allowed to rise. The IPTS is still monitoring the pressure and temperature in the rail to ensure there is liquid in the rail.
7	Crank	Once liquid is detected in the rail, the PCM engages the starter, and starts the vehicle.

General Propane Tank Filling

The most important aspect of filling a propane tank is safety. Understanding the properties, characteristics, and safe handling practices of the fuel is required before conducting any propane tank filling efforts.

A propane-powered vehicle is equipped with a propane tank built and certified to the regulations of the American Society of Mechanical Engineers (ASME). These tanks have a data plate with pertinent information including the ASME stamp. This plate must be securely attached and legible or the tank should be taken out of service and replaced.

There are no requirements for recertifying ASME tanks, however, inspection is required and maintenance is recommended if there are signs of corrosion. Propane tanks are filled to 80% water capacity to allow for the liquid fuel to expand and contract, depending on ambient temperatures. All tanks built for use on motor vehicles are equipped with an overfilling prevention device (OPD). The National Fire Protection Association (NFPA) requires motor vehicle propane tanks be equipped with an overfill prevention device to automatically prevent filling the tank beyond the maximum recommended capacity of 80%. This automatic stop fill system prevents overfilling of the fuel tanks. This requirement has been in effect since January 1, 1984.

Propane Tank Refueling Procedure

The vehicle is equipped with an 80% overfill prevention device, therefore it is not required that the liquid level gauge or bleeder valve be opened during regular refueling.

Follow the instructions of your fuel station provider when refueling the vehicle. It is required that the nozzle output pressure be at least 25 psi higher than vehicle tank pressure for the vehicle to fill.

OPD Inspection Procedure

Some companies or local governing bodies may require an annual overfill prevention device (OPD) inspection on propane vehicles. This procedure tests that the OPD is stopping fuel fill at the correct 80% level.

⚠ DANGER

Always follow all NFPA 58 guidelines. When working on the propane fuel system or refueling a vehicle, you must be in a well-ventilated area at least 25 ft from any ignition source and 35 ft from any activity that throws sparks. Failure to heed this danger may result in severe personal injury or death.

Leaked or vented propane will expand quickly when no longer pressurizing in the fuel system. Liquid propane expands at a ratio of 1:270 going from a liquid to vapor. Propane vapor is heavier than air and seeks the lowest point. When the ratio of propane to air is between 2.2% and 9.6%, propane will burn in the presence of an ignition source at 940°F (504°C) or hotter. Keep away from heat, sparks, flames, static electricity, lighted smoking materials, or other sources of ignition. Failure to heed this danger may result in severe personal injury or death.

Liquid propane is cold. When liquid propane is released from a pressurized vessel, it rapidly evaporates, creating a refrigeration effect that can cause frostbite. Wear non-porous, cold-safe gloves, eye protection, and ear protection during venting and repair operations. Keep moisture away from the valves. Failure to heed this warning can result in personal injury.

NOTE: Test must be performed when the vehicle has less than 50% fuel level, as indicated on the cluster.

1. Locate the vehicle propane tank data plate and reference the tank volume, often listed as W.C. (water capacity).
2. Calculate 5% of the W.C. This is the number of gallons the vehicle can fuel once liquid is visible at the bleeder valve.
3. Park the vehicle at a fill station or near a refueling truck on level ground. Place a level on the frame rail or tank to ensure it is level.
4. Connect the fill nozzle to the vehicle fill valve.
5. Open the vehicle bleeder valve. You should have clear vapor emitting from the valve.
6. Begin filling per the refueling station manufacturer's procedure.
7. Once liquid (seen as an opaque white mist) is visible at the bleeder valve, stop fueling.
8. Close the bleeder valve.
9. Record the number of gallons filled and determine your maximum fill amount by adding the calculated 5% from Step 2.
10. Continue filling. The tank should stop taking fuel before the calculated maximum fill level is reached. If you reach the maximum fill level, and the tank is still taking fuel, stop fueling and contact ROUSH CleanTech customer support at 800.59.ROUSH.
11. Turn off the fuel pump, disconnect the nozzle, and replace the fill cap.

NOTE: The tank may have stopped filling before consistent liquid was visible at the bleeder. This indicates normal operation.

Fuel System Overview

Figure 1 – Fuel System Overview

SERVICE PREPARATION

Manual Fuel Shutoff

NOTE: This procedure ensures that no propane leaves the fuel tank during service activities.

Closing the Manual Fuel Shutoff

1. Locate the supply valve assembly on the tank.
2. Turn the manual shutoff valve on the supply valve assembly clockwise by hand until it stops to close it. Do not tighten with a tool.

Opening the Manual Fuel Shutoff

1. After fuel system service is completed, open the manual shutoff valve on the tank by turning it counter-clockwise until it stops.
2. Follow the *Fuel System Priming Procedure*.

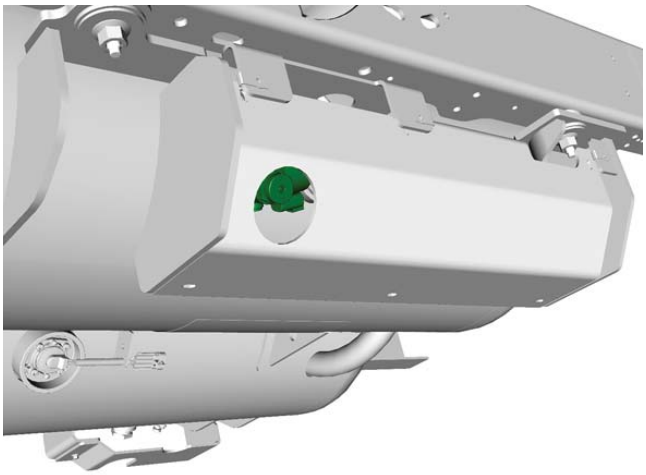

Figure 2 – Manual Shutoff

Fuel System Purge, Evacuation, and Priming Procedures

⚠ DANGER

Always follow all NFPA 58 guidelines. When working on the propane fuel system or refueling a vehicle, you must be in a well-ventilated area at least 25 ft from any ignition source and 35 ft from any activity that throws sparks. Failure to heed this danger may result in severe personal injury or death.

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Liquid propane is cold. When liquid propane is released from a pressurized vessel, it rapidly evaporates, creating a refrigeration effect that can cause frostbite. Wear non-porous, cold-safe gloves, eye protection, and ear protection during venting and repair operations. Keep moisture away from the valves. Failure to heed this warning can result in personal injury.

Fuel Line Purging

Clearing the propane out of the fuel lines (purging) is required before working on many fuel system components. Following the suggested techniques for purging the fuel lines will reduce the amount of vapor released harmlessly into the atmosphere and will produce the least risk to life and property.

1. Park the vehicle in well-ventilated area away from any ignition source.
2. Close the manual shut-off valve on the tank supply valve.
3. Disconnect the fuel pump electrical connectors at the fuel tank access cover.
4. Start the engine and let it run until it stalls. This purges the supply and return fuel lines of some liquid propane.
5. Turn off the ignition and disconnect the negative battery terminal.
6. Slowly loosen the fuel line connection at the outlet of the in-line supply filter.

⚠ CAUTION

Watch for liquid propane dripping from the line connection.

7. Slowly open the line at the return valve on tank to allow the remaining fuel to bleed off.
8. Tighten fuel line fitting at the filter to 28 Nm (21 ft-lb) and the fuel line at the return valve to 31 Nm (23 ft-lb).
9. Clear any fault codes set by this procedure.

⚠ CAUTION

There may still be a small amount of propane in the lines after running this procedure. Open the lines slowly and cautiously to bleed off any remaining propane.

Fuel System Priming Procedure

After performing any fuel system service work where the fuel lines were depressurized, the fuel system must be leak checked and primed. This will prevent the excess flow valve from checking as fuel quickly fills the empty fuel lines.

See Fuel System Description and Operation at the beginning of this chapter for detailed operation of the purge cycle.

1. Leak check all valves and line connections that were serviced using an electronic leak detector or leak detection solution.
2. Make sure the battery is connected.
3. Check to make sure there is fuel in the tank, manual shutoff valve is closed, and the fuel pumps are connected.
4. Turn the key to the START position. When you hear the fuel pumps activate, slowly open the manual shutoff valve.
5. If vehicle does not start, close the manual shutoff valve and repeat the process.

Fuel Tank Draining Procedure

⚠ DANGER

Always follow all NFPA 58 guidelines. When working on the propane fuel system or refueling a vehicle, you must be in a well-ventilated area at least 25 ft from any ignition source and 35 ft from any activity that throws sparks. Failure to heed this danger may result in severe personal injury or death.

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Overview

A propane fuel tank must be empty of propane before most tank components can be serviced or be transported by a carrier. There are three ways to evacuate fuel from the tank: transferring the fuel to another vessel, burning off the fuel through a flare tower, or venting the fuel to atmosphere.

Due to the volume of fuel likely to be retained in the fuel tank, releasing the vapor to the atmosphere is a slow procedure without special equipment as it must be done through the bleeder valve. This is mandated by NFPA 58 regulations. If using a transfer/evacuation system or flare tower, follow the manufacturer's instructions. If not already equipped, it is suggested that a local, certified propane handling company be engaged to purge the fuel tank and recapture the fuel as the need requires.

Verifying Tank Depressurization

WARNING

Technicians working with, or around, fuel systems should be properly trained to utilize extreme care and caution at all times. Failure to exercise extreme caution and care may lead to serious accidents which can result in property damage, personal injury and/or death.

Before removing any components from the fuel tank it is very important to verify there is no pressure remaining. The technician that is removing a tank component should always be the one to verify it is empty. This should be done right before starting the repair. This procedure will test for pressure in the tank even if there is a component failure.

1. The tank should be depressurized using your preferred NFPA 58 approved method. Refer to the *Fuel Tank Draining Procedure* in the ROUSH CleanTech service manual for your vehicle.
2. Also perform the *Fuel Line Purging Procedure* from the ROUSH CleanTech service manual.
3. Once the tank is empty. Open the bleeder valve. Ensure that no fuel is escaping. Repeat 2 times, closing and opening the bleeder valve to ensure the valve is not stuck.

Figure 3 – Bleeder Valve

4. Check the sending unit external twin-site and ensure the needle is on E.

Figure 4 – Sending Unit

5. Key the vehicle to the On position. Using a capable OBDII scan tool, monitor fuel rail pressure (FRP).
6. Open the manual shut off valve.

Figure 5 – Manual Shut Off Valve

7. Key the vehicle to the start position. Then after five second key it to Off.
8. Key the vehicle to On and measure fuel rail pressure.
9. If pressure is below 15 psi, components can be removed from the tank, following the replacement procedure in the ROUSH CleanTech service manual.

NOTE: For components threaded into the tank, slowly loosen them. For components fastened to the tank with a flange, slowly loosen each bolt until the component can move freely, then the component can be removed from the tank.

10. If pressure is above 15 psi, repeat steps 2-8. If after the second attempt pressure is still above 15psi, contact ROUSH CleanTech for further instruction.

⚠ CAUTION

After depressurizing, there will still be propane vapors in the tank. Keep tank away from any sources of ignition. A de-pressurized tank can re-pressurize if left sealed.

Using In-Tank Pumps

Use of the in-tank pumps to drain the tank is an acceptable method assuming at least one of the two pumps and the supply valve are functioning normally. Temperature can affect transfer rates. Information on the ROUSH CleanTech transfer kit and procedures can be viewed at roushcleantech.com/service.

NOTE: This method will not completely drain the tank and a final process of venting the tank will still be required. In some areas, it is not allowed or may not be safe to vent the fuel to the atmosphere. In this case, the fuel must be burned off.

1. Move the vehicle to an outdoor, well-ventilated area at least 25 feet from any external ignition sources.
2. Place the tank in which the fuel is to be captured close to the tank to be drained.
3. Purge the fuel lines by using the *Fuel Line Purge Procedure*.
4. Disconnect supply line from forward side of inline filter at front of fuel tank.
5. Connect the fuel transfer hose to the receiving tank fill valve.
6. Connect the transfer hose to the forward side of filter that line was removed from in Step 4.
7. Disconnect the fuel pump wire harness at the tank access cover and connect a switch to the fuel pump wire connectors.
8. Open the automatic supply valve on the tank to be drained, this requires 12V power to the supply solenoid.
9. Turn the switch on the jumper harness to the ON position.
10. Slowly open the manual supply valve on the tank to be drained. You should hear the pumps in the fuel tank running and fuel will begin to transfer to the capture fuel tank.
11. When the liquid propane level in the fuel tank drops below the fuel pumps pickup tube, the pump will make a different sound. Turn the switch OFF immediately to stop the pump.

NOTE: Running fuel pumps without liquid in them will cause damage to the pumps and lead to premature failure.

12. Manually close the supply valve on the vehicle tank.
13. Loosen the fuel transfer hose and bleed off the fuel pressure.

⚠ CAUTION

Fuel will be under pressure in the transfer line; use caution when disconnecting the fittings, slowly loosen the fittings, and use gloves and protective eye wear.

14. The remaining fuel in the tank will now need to be evacuated through the bleed valve.

NOTE: The tank can be evacuated using a flare stand, if the service center is equipped with a stand and has received the proper training. If using a flare stand to burn off the remaining fuel in the tank, this would require approximately a 50-foot clearance from the vehicle, other vehicles, a building, or any combustible materials. Follow the manufacturer's instructions for your flare stand.

⚠ CAUTION

Some states and municipalities may have regulations preventing the release of LPG into the atmosphere. Check with your local fire marshal or your local LPG supplier prior to venting or burning off a tank.

15. When the tank is no longer venting or burning off propane, perform the *Verifying Tank Depressurization Procedure*.

NOTE: If you have any questions or concerns or you feel unqualified to perform the process of venting the tank, contact your local fuel system provider or ROUSH CleanTech 800.59.ROUSH.

Fuel Tank Purging Procedure

The following procedure is required to purge the air from the fuel tank after servicing tank components.

1. Fill the tank with one (1) gallon of propane and cycle the ignition key to the CRANK position and then to the OFF position. (Do not allow the vehicle to start during this step.)
2. Leak check all tank valves and line connections using an electronic leak detector or leak detection solution.
3. Open the bleeder valve for 20 minutes or until propane stops bleeding, whichever comes first. Close the bleeder valve.
4. Fill with approximately 20 gallons of propane.
5. Close the bleeder valve.

NOTE: When filling an empty tank, start filling at a slow rate to build up pressure inside the tank. An initial fast fill may trip the OPD, creating a slow or no fill condition.

6. Perform a final leak inspection at all fuel fill and fuel line connections to ensure no leaks are present using an electronic leak detector or leak detection solution.

SPECIAL TOOLS

Electronic Leak Detector

If purchasing an electronic leak detector, it is recommended to use a tester capable of detecting down to 35 PPM of propane vapor.

Leak Detecting Solution

Leak detecting solution should be used to inspect seals and connections after servicing the fuel system.

Fuel Transfer Kit

There are several fuel transfer kits available, including the ROUSH CleanTech transfer kit. Information is available at roushcleantech.com/service.

Flare Tower

A flare stand/tower can be used to burn off vented propane during servicing. If using a flare tower, we recommend purchasing one from a reputable supplier, such as: www.flameengineering.com/Propane_Flare.htm.

⚠ WARNING

Do not attempt to build your own flare tower. Failure to exercise extreme caution and care may lead to serious accidents which can result in property damage, personal injury, and/or death.

Some states and municipalities may have regulations preventing the release of LPG into the atmosphere. Check with your local fire marshal or your local LPG supplier prior to venting or burning off a tank.

FUEL SYSTEM COMPONENT SERVICE

Fuel Tank

Description

The LPA system utilizes a dual cylindrical manifold tank assembly to store the liquid propane. The two cylinders are permanently connected by mounting brackets and crossover tubes that create a single volume of fuel and are considered a single fuel tank assembly. The fuel tank is designed and certified to meet all applicable safety standards required for installation on a motor vehicle. The tank design includes structural mounting brackets, which are used for mounting the tank assembly between the frame rails. The tank assembly is secured to the chassis using specially coated and grade level fasteners.

In addition, the tank is fitted with a pressure relief valve (PRV) that will open if tank pressure exceeds 312 psi or 375 psi, depending on application, protecting the integrity of the tank.

The following components are mounted to the outside of the fuel tank: fixed liquid level gauge (bleeder valve), supply circuit assembly, return circuit assembly, pressure relief valve, overfill prevention device, fuel pressure and temperature sensor (FPTS), and fuel level sender. The LPA fuel tank is fitted with a service port flange for accessing the internals of the tank. The following components are located inside the fuel tank: dual electric fuel pumps with an inlet filter, jet pump, and a wiring harness.

The tank components and their functions will be provided individually in this manual.

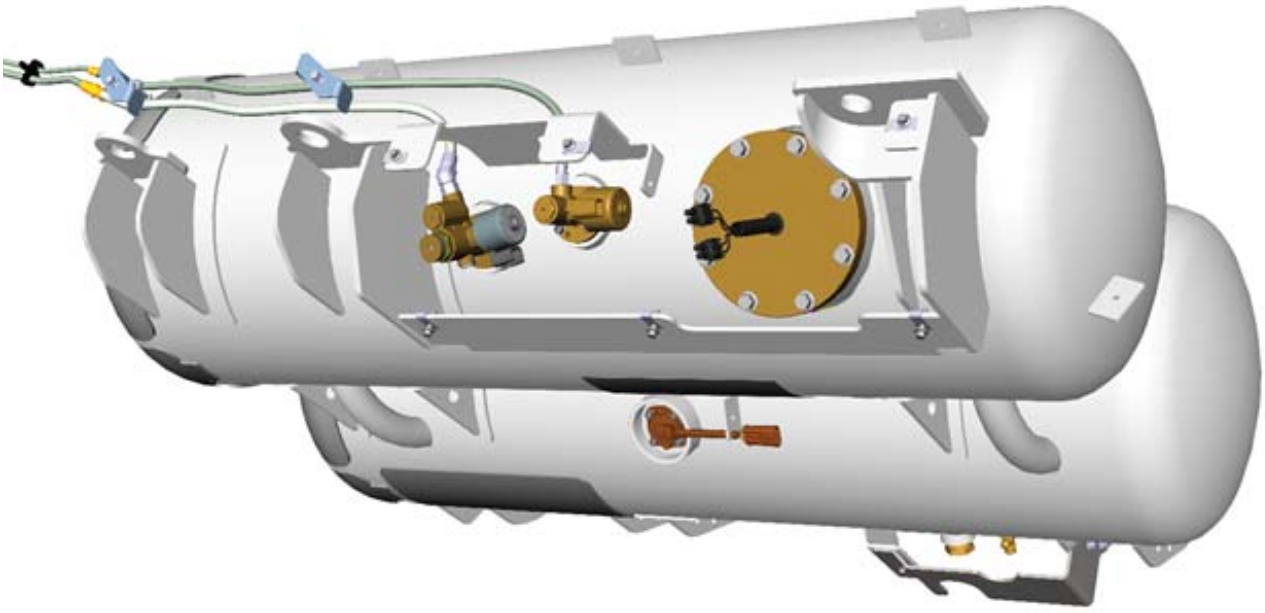

Figure 6 – 53-Inch Tank Left Side

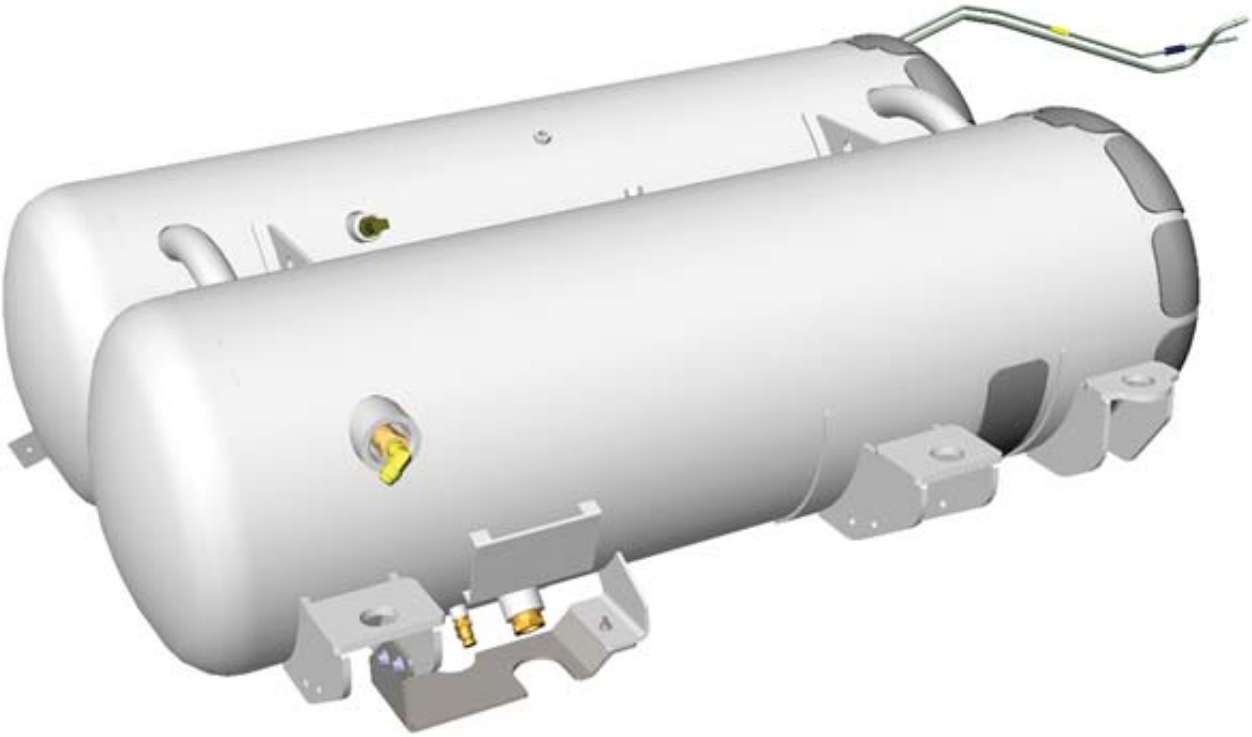

Figure 7 – 53-Inch Tank Right Side

Removal

1. Purge the fuel lines using the *Fuel Line Purging Procedure*.
2. If the tank is being replaced or will be opened for service, drain the fuel tank using the *Fuel Tank Draining Procedure*.

NOTE: If the tank does not need to be serviced and will be removed with propane inside, be sure the manual shutoff and tank bleeder valves are securely closed.

3. Disconnect the supply and return line from the tank valves and unclip from retention points.
4. Remove the fill hose from the fill valve.

5. Disconnect all tank electrical connections.
6. Obtain a hoist capable of safely lifting 1,000 lb (373 kg). Attach the hoist to the fuel tank using lifting straps. Support the tank while removing the tank mounting fasteners.
7. Remove the fasteners attaching the tank to the frame rails. Depending on the tank length, there will be four (4) or six (6) mounting points.

NOTE: Retain steel washers, rubber isolators, and crush limiters.

8. With the help of an assistant, lower the tank.

Replacement

1. Using the hoist, carefully raise the fuel tank into position. Ensure the steel washers, rubber isolators, and crush limiters are installed in the order shown.

⚠ CAUTION

Take care not to pinch fuel lines or wire harnesses.

2. Connect all wiring connections.
3. Install tank mounting fasteners. Torque to 105 Nm (77 ft-lb).
4. Connect the fuel supply line to the supply valve. Torque to 31 Nm (23 ft-lb).
5. Connect the return line to the return valve. Torque to 31 Nm (23 ft-lb).
6. If the tank was emptied, perform *Fuel Tank Purging Procedure*.
7. Leak check tank valves and line connections.
8. Perform *Fuel System Priming Procedure*.

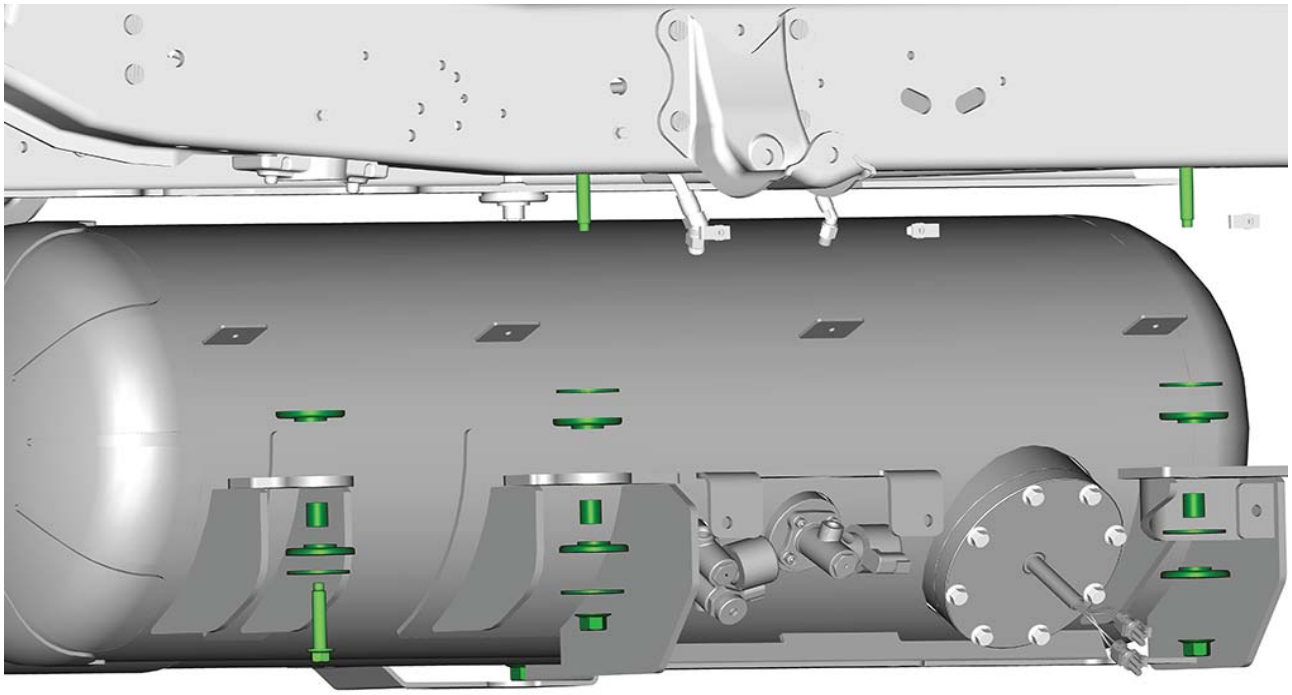

Figure 8 – Fuel Tank Removed

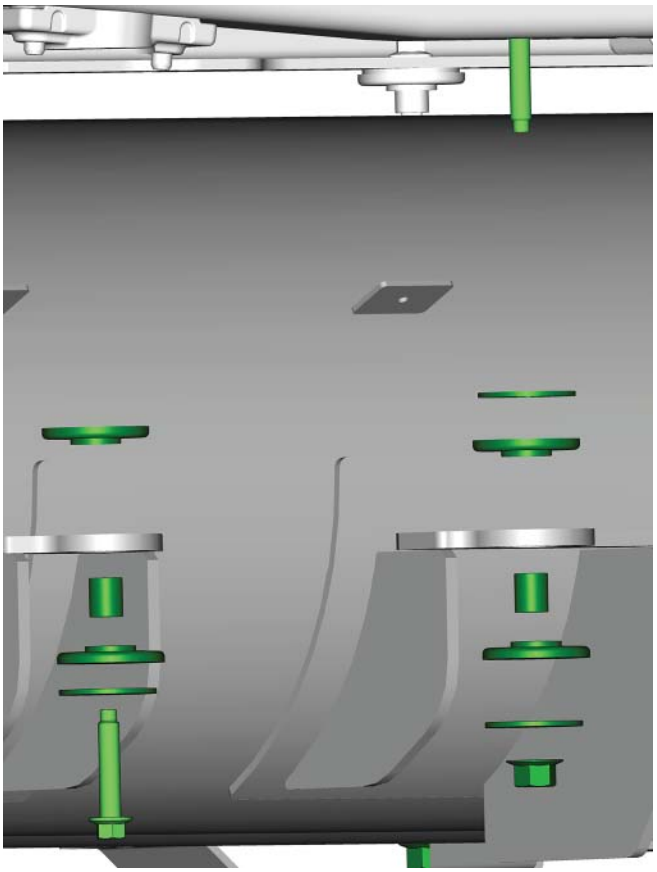

Figure 9 – Crush Limiters

Tank Cover Plate

Description

The tank cover plate protects the tank valves. It has a small circular opening to allow access to the manual shutoff valve without having to be removed.

Removal

1. Remove the six (6) fasteners securing the tank cover plate to the tank.
2. Lower the plate and inspect that J-clips are retained and in good condition.

Replacement

1. Align tank cover plate and thread the six (6) fasteners half-way in, making it easier to install them.
2. Torque all six (6) fasteners to 10 Nm (88.5 in-lb).

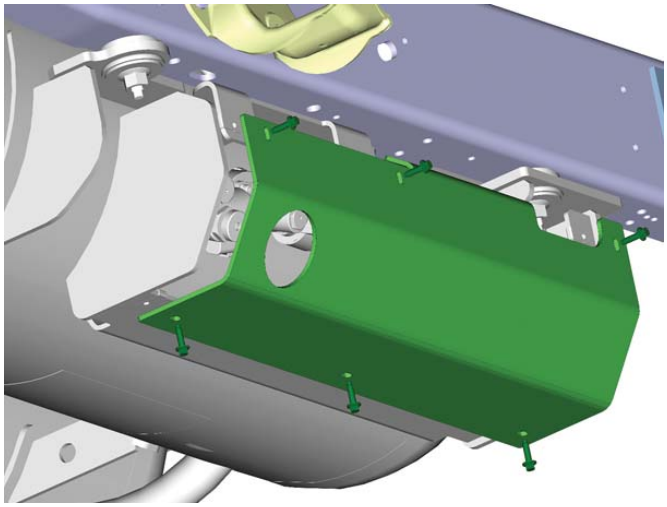

Figure 10 – Tank Cover Plate

Fill Filter

Description

The fill filter is located on the fill line and filters fuel going into the tank. It has a 5-micron filter element to capture particulates. It is non-bypassing and will slow refueling if it becomes clogged. This filter should be replaced every 50,000 miles.

Removal

1. Slowly loosen the fitting(s) at the filter to drain the fill lines.

⚠ WARNING

This line will be pressurized with liquid propane. Follow all safety precautions described in this manual.

2. Disconnect the fuel fill line from the fuel filter inlet and outlet.
3. Remove the clamp retaining the fuel filter to the body.
4. Remove and discard the filter.

NOTE: Depending on body and bumper clearance, you may have to remove the two (2) bracket mounting bolts and lower the bracket.

Replacement

1. Connect the fuel fill lines to the filter inlet and outlet and torque to 57 Nm (42 ft-lb). Note filter orientation. There will be an arrow on the filter indicating the direction of flow.

2. Secure the fuel filter using the originally installed clamp.
3. If you removed the filter bracket, replace the bracket and install the two (2) mounting bolts. Torque to 10 Nm (7.4 ft-lb).
4. Connect the fill valve to a fuel dispensing source to charge the line.
5. Check all fittings for leaks using an electronic leak detector or leak detection solution.

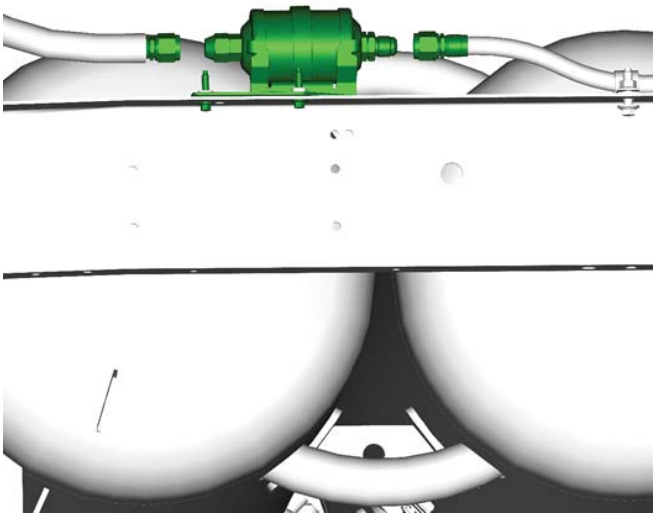

Figure 11 – Fill Filter

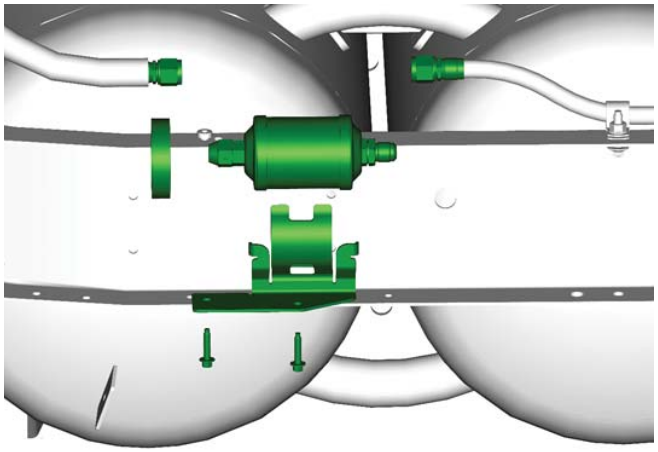

Figure 12 – Fill Filter

Tank Fill Valve/Overfill Prevention Device (OPD)

Description

Located where fuel enters the fuel tank, the fill valve is opened mechanically by the refueling pump pressure during the fill process. It also incorporates a back-flow check valve and an OPD that stops the fill at 80%. The back-flow check valve closes when vehicle tank pressure is greater than pressure outside of the tank to prevent fuel from escaping.

Removal

1. Park the vehicle outside in a well-ventilated area.
2. Slowly loosen the fuel line connecting to the OPD.

⚠ WARNING

This line will be pressurized with liquid propane. Follow all safety precautions described in this manual.

3. Drain the fuel tank using the *Fuel Tank Draining Procedure*.
4. Remove the fuel tank using the *Fuel Tank Removal Procedure*.
5. Remove the OPD.

Replacement

NOTE: New OPDs come with sealant already applied to the threads. If reusing an OPD, clean the threads and apply Everseal PLS2 to the threads.

1. Take note of the “Top” mark on the face of the OPD.
2. Install the OPD and torque to 91 Nm (67 ft-lb).
3. Set a torque wrench to 130 Nm (96 ft-lb) and slowly rotate the OPD clockwise until the “Top” mark is at the 12 o’clock position. Ensure the wrench does not reach torque. Do not turn the valve counter-clockwise.

⚠ CAUTION

Do not exceed 130 Nm (96 ft-lb) as it could damage the part. If you achieve 130 Nm (96 ft-lb), remove and discard the OPD. A new part will be required.

4. Connect the fuel fill line to the OPD and torque to 45 Nm (33 ft-lb).
5. Perform the *Fuel Tank Purging Procedure*.

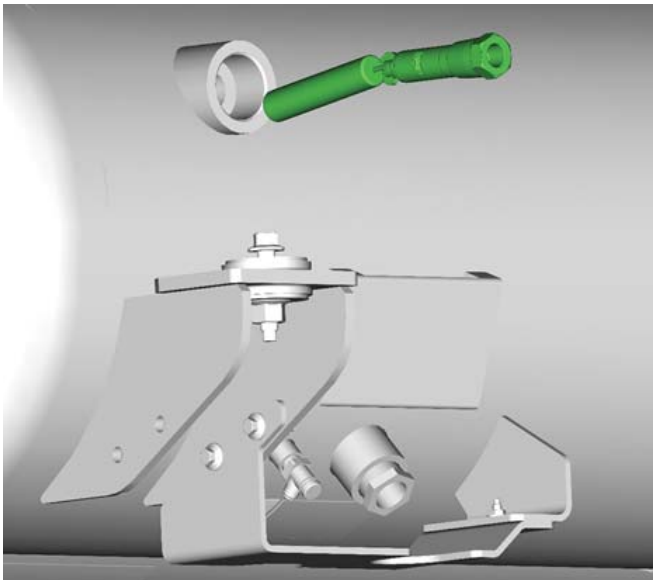

Figure 13 – OPD

Tank Bleeder Valve/Liquid Level Gauge

Description

The tank bleeder valve is located on the bottom side of the tank and is connected to a steel tube that goes up to the 80% mark on the tank. The bleeder valve serves 3 functions.

- -4 AN fitting where a pressure gauge can be connected to read tank pressure
- A liquid level gauge used in the *OPD Inspection Procedure*
- A means of slowly bleeding the tank

Removal

1. Drain the fuel tank using the *Fuel Tank Draining Procedure*.
2. Remove the bleeder valve.

Replacement

NOTE: New bleeder valves come with sealant already applied to the threads. If reusing the bleeder valve, clean the threads and apply Everseal PLS2 to the threads.

1. Install the bleeder valve
2. Using a crowfoot wrench, torque the bleeder valve to 24 Nm (17.7 ft-lb).
3. Rotate the bleeder valve clockwise until the nozzle points straight downward. Do not reverse orientation.
4. Perform the *Fuel Tank Purging Procedure*.

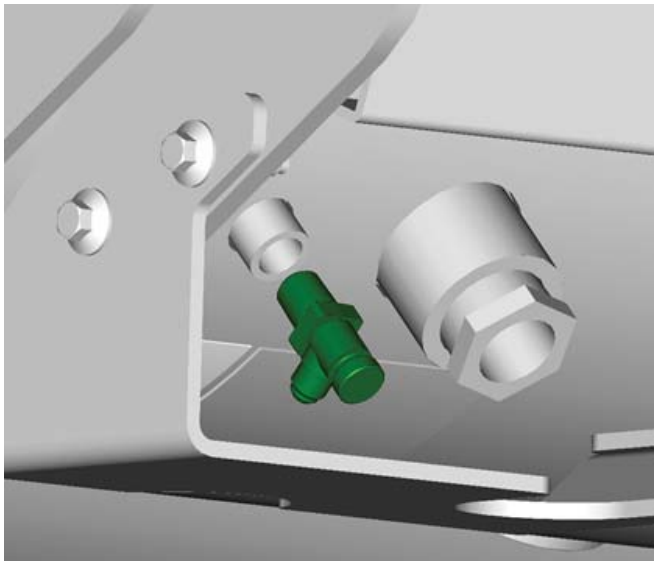

Figure 14 – Bleeder

Fuel Tank Pressure Relief Valve (PRV)

Description

The PRV is a safety device that will vent propane vapor out of the tank if the tank exceeds the maximum rated pressure. This would occur if the tank was subjected to extreme temperatures (propane tank pressure changes with temperature) or the tank is overfilled. Depending on vehicle market, this valve is set to vent at 312 psi (approximately 146°F) or 375 psi (approximately 161°F). The PRV activating would be noticed by a loud popping sound followed by a cloud of propane vapor. The valve will reseal once pressure is lowered.

NOTE: If the PRV activates, it must be replaced as the calibration of the spring could be compromised.

Removal

1. Perform *Fuel Tank Draining Procedure*.
2. Remove the PRV.

Tank Supply Valve Assembly

Description

The supply valve assembly is mounted to the tank and connects to the fuel pumps and supply line. It has three main functions.

Tank Solenoid Valve

The tank solenoid is an electrically operated automatic shutoff valve. It is located downstream from the excess flow valve and manual shutoff valve. The tank solenoid is normally in a closed position (de-energized), preventing the flow of fuel to the engine. When the ignition key is turned ON to start the vehicle, power is supplied to the solenoid opening the valve and allowing fuel to flow from the tank to the engine. The tank solenoid will close when the ignition is shut off, or if the engine stalls (with ignition on).

Manual Shutoff Valve

The manual shutoff valve is used to seal the outlet of the tank during shipping, service, or in case of a vehicle failure. It is located between the excess flow valve and tank solenoid valve. It is manually operated by turning the knurled knob mounted on the front of the supply circuit assembly. Turning the knob clockwise closes the valve and turning the knob counterclockwise opens the valve. It should always be open when the vehicle is operating.

Excess Flow Valve (XFV)

The excess flow valve is located in the supply fuel path, ahead of the tank solenoid and manual shutoff valve. The valve is intended to shut off fuel flow from the tank in the event of a rapid pressure drop outside the fuel tank. A rapid pressure drop could be caused by a severed line or an inadvertent disconnect without shutting the Manual Shutoff Valve. If the excess flow valve trips (may happen after servicing the system), it can be reset by closing the manual shutoff valve and then slowly opening it. The excess flow valve does not completely stop flow and will not actuate with smaller leaks, so it should not be relied on for servicing purposes. If the excess flow valve activates (such as immediately following service where the system may not be primed with fuel), turn OFF the key and wait 15-30 seconds, then retry.

Removal

1. Purge the fuel lines using the *Fuel Line Purging Procedure*.
2. Drain the fuel tank using the *Fuel Tank Draining Procedure*.
3. Remove the tank cover plate using the *Tank Cover Plate Removal Procedure*.
4. Remove the supply line at the valve. Inspect O-ring and replace if damaged.
5. Disconnect the supply solenoid electrical connection.
6. Slowly loosen the four (4) bolts evenly securing the valve to the tank until you can move the valve.
7. Remove the four (4) bolts securing the valve to the tank.
8. Pull the supply circuit assembly away from the tank.
9. Disconnect the internal fuel pump supply line by depressing the colored tabs on either side of the quick connect fitting and pulling it off the stem.
10. Remove and discard the O-ring from the bottom of the supply valve.

Replacement

NOTE: When replacing the supply valve assembly, the tank seat O-ring must be replaced.

1. Inspect the O-ring sealing surface and remove any debris.
2. Apply silicone O-ring lubricant (Parker Super Lube or equivalent) to the O-ring and install to the supply solenoid.
3. Lubricate the tip of the brass stem quick connect with a small amount of motor oil.
4. Connect the internal fuel pump supply line, push on until a “click” is heard, then tug to insure it is secured.
5. Slide the supply valve assembly to the tank seat.
6. While holding the supply circuit valve assembly, install the four (4) bolts and hand tighten.
7. Torque the bolts to an initial torque: Crossing pattern 2.5 Nm (22 in-lb).
8. Torque the bolts to a final torque: Crossing pattern 10 Nm (7.4 ft-lb).
9. Inspect the fuel line O-ring and install to the supply valve, torque to 31 Nm (23 ft-lb).
10. Connect the wiring harness to the tank solenoid coil.
11. Purge the fuel tank using the *Fuel Tank Purging Procedure*.
12. Check the supply valve and tank lines for leaks using an electronic leak detector or leak detection solution.

13. Install the tank cover plate using the *Tank Cover Plate Replacement Procedure*.
14. Perform the *Fuel System Priming Procedure*.

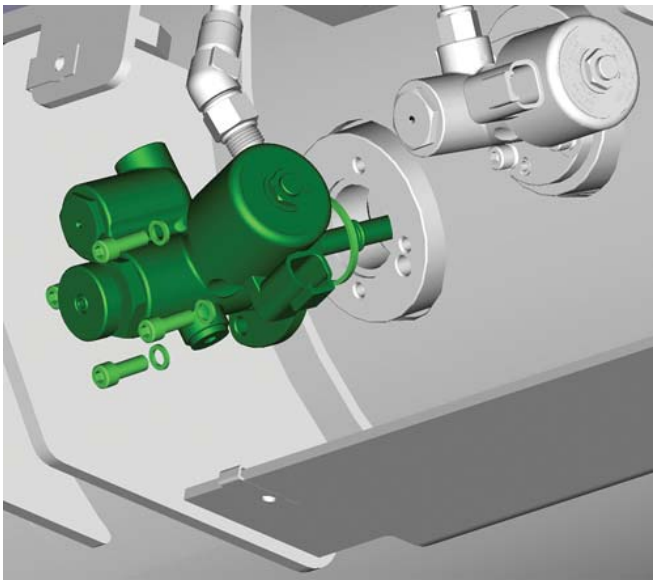

Figure 15 – Supply Valve Assembly

Return Valve Assembly

Description

The fuel return valve on the tank incorporates a check valve, which prevents fuel from flowing from the tank into the return line. The fuel return valve also contains the flow control solenoid (FCS) which includes a small orifice to restrict return flow in normal conditions as well as a bypass circuit to allow maximum fuel flow prior to engine starting or during extremely hot conditions.

Removal

1. Purge the fuel lines using the *Fuel Line Purging Procedure*.
2. Drain the fuel tank using the *Fuel Tank Draining Procedure*.
3. Remove the tank cover plate using the *Tank Cover Plate Removal Procedure*.
4. Remove the fuel return line from the return valve. Inspect the O-ring and replace if damaged.
5. Slowly loosen the four (4) bolts evenly securing the valve to the tank until you can move the valve.
6. Remove the four (4) bolts securing the valve to the tank.
7. Carefully pull the valve outward so that you do not pull the return fuel line out of its in-tank retention clip.
8. Retain the hose with a small set of locking pliers. Take care not to kink or damage the hose.
9. Remove the return hose from the return valve quick connect fitting.

Replacement

1. Inspect the O-ring sealing surface and remove any debris.
2. Apply silicone O-ring lubricant (Parker Super Lube or equivalent) to the O-ring and install to the supply solenoid.
3. Lubricate the tip of the brass stem quick connect with a small amount of motor oil.
4. Connect the internal return line, push on until a “click” is heard, then tug to insure it is secured. Take care not to let the hose fall back into the tank.
5. Slide the supply valve assembly to the tank seat.
6. While holding the supply circuit valve assembly, install the four (4) bolts and hand tighten.
7. Torque the bolts to an initial torque: Crossing pattern 2.5 Nm (22 in-lb).
8. Torque the bolts to a final torque: Crossing pattern 10 Nm (7.4 ft-lb).
9. Inspect the fuel line O-ring and install to the supply valve, torque to 31 Nm (23 ft-lb).
10. Connect the wiring harness to the tank solenoid coil.
11. Purge the fuel tank using the *Fuel Tank Purging Procedure*.
12. Check the supply valve and tank lines for leaks using an electronic leak detector or leak detection solution.
13. Install the tank cover plate using the *Tank Cover Plate Replacement Procedure*.
14. Perform the *Fuel System Priming Procedure*.

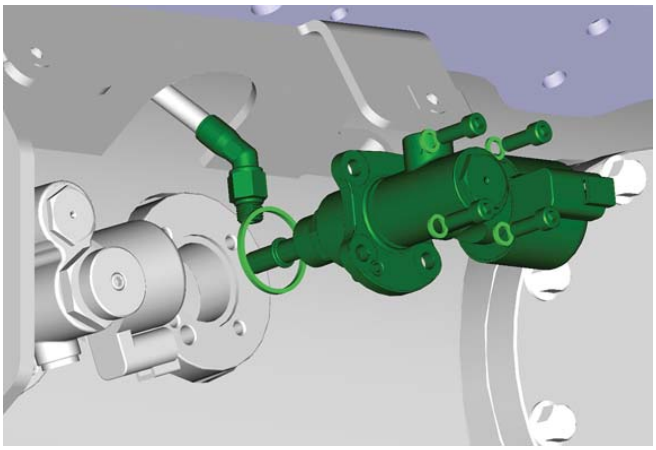

Figure 16 – Return Valve

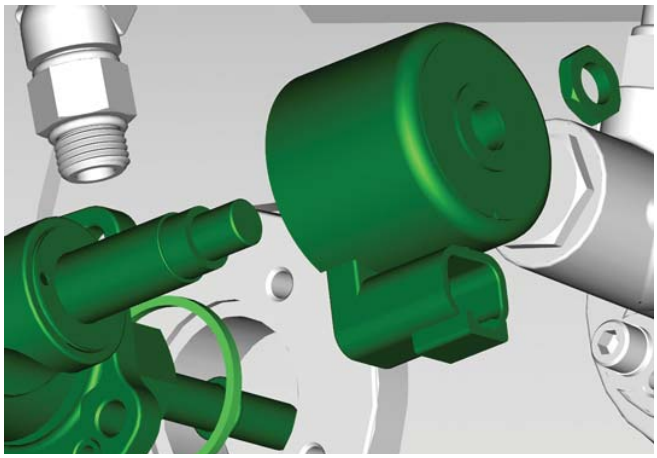

Figure 17 – Supply Valve and Solenoid

Solenoid Coils

Description

The same solenoid coil is used on the supply valve, return valve, and FRPCM. It is a 12V coil that when energized, opens a valve. The coils can be replaced independently of the valve assembly without depressurizing the fuel system.

Removal

1. Disconnect vehicle battery and remove 2-pin connection from solenoid to be serviced.
2. Note the coil orientation.
3. Remove the nut holding the coil onto the solenoid post.
4. Slide coil off the post.

Replacement

1. Slide new coil onto the post.
2. Position the coil in its original orientation. For the FRPCM, align the two (2) coil connectors with a straight edge.
3. Install the nut which holds on the coil and torque to 5.4-5.5 Nm (47.5-48.5 in-lb).
4. Reconnect electrical connector to solenoid coil.
5. Reconnect vehicle battery.
6. Start vehicle and perform KOEO/KOER self-test to ensure vehicle is repaired and solenoid faults do not persist.

Tank Access Flange

Description

The tank access flange serves as a wire pass-through for the fuel pumps and allows access into the tank.

Removal

1. Drain the fuel tank using the *Fuel Tank Draining Procedure*.
2. Remove the tank cover plate using the *Tank Cover Plate Removal Procedure*.
3. Ensure the negative battery cable is disconnected.
4. Disconnect the external fuel pump connectors.
5. Slowly remove the tank service cover from tank, loosening bolts in a star-pattern a small amount each time until the cover is loose. This will ensure no pressure is present.
6. Reach into the fuel tank and disconnect the fuel pump electrical connectors.
7. Discard the access flange O-ring.

Replacement

1. Inspect the access flange mounting surface on the tank and remove any debris.
2. Apply silicone O-ring lubricant (Parker Super Lube or equivalent) to the new O-ring and install into the groove in the tank access flange.
3. Move the access flange near the port and connect the internal fuel pump connectors.
4. Install the access flange on the tank and hand-tighten the eight (8) screws.

5. Torque in a cross pattern to an initial torque of 3 Nm (26.5 in-lb).
6. Torque in a cross pattern to a final torque of 40.6 Nm (30 ft-lb).
7. Connect the external fuel pump connectors.
8. Purge the fuel tank using the *Fuel Tank Purging Procedure*.
9. Check the supply valve and tank lines for leaks using an electronic leak detector or leak detection solution.
10. Install the tank cover plate using the *Tank Cover Plate Replacement Procedure*.
11. Perform the *Fuel System Priming Procedure*.

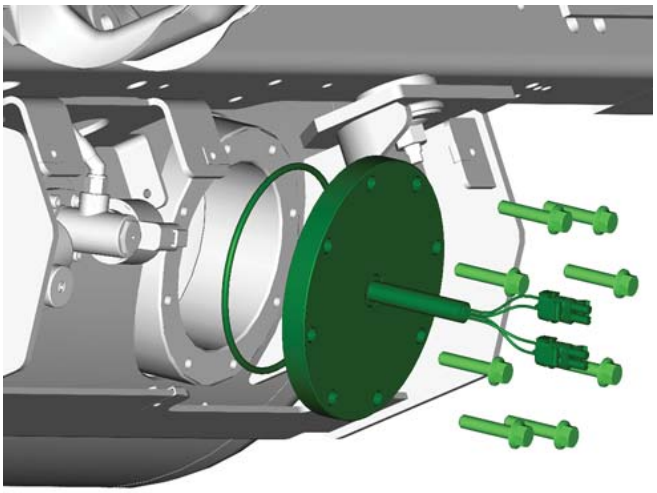

Figure 18 – Access Flange

Fuel Pumps

Description

The ROUSH CleanTech fuel system uses two (2) fuel pumps that pump in parallel to push liquid propane up to the engine, and maintain liquid in the fuel rail. They come together in a Y at the supply valve. The fuel pumps are serviced as an assembly.

Removal

1. Drain the fuel tank using the *Fuel Tank Draining Procedure*.
2. Remove the tank cover plate using the *Tank Cover Plate Removal Procedure*.
3. Ensure the negative battery cable is disconnected.
4. Remove the tank access flange using the *Tank Access Flange Removal Procedure*.

⚠ WARNING

Use caution when working inside the fuel tank. There could be a flammable mixture of propane and air inside the tank when it's open. Do not use electric tool inside or near an open tank.

5. Release the two (2) fuel pump hose quick connects.
6. Remove the center 8 mm bolt.
7. Remove the two (2) 10 mm nuts from the top corners of the pump.
8. Pull the full pump assembly forward off the studs, then lift slightly upward, and remove it from the tank bottom first.

NOTE: The fuel pumps are serviced as an assembly.

Replacement

1. Place the new pump assembly on the two (2) fuel pump mounting studs.
2. Install the center bolt and torque to 5.8 Nm (4.3 ft-lb).
3. Install the two (2) nuts on the pump bracket studs and torque to 8.5 Nm (6.3 ft-lb).
4. Connect the fuel pump electrical connectors.
5. Install the tank access flange using the *Tank Access Flange Replacement Procedure*.
6. Purge the fuel tank using the *Fuel Tank Purging Procedure*.

NOTE: During the *Fuel Tank Purging Procedure*, after filling with 15 gallons of fuel, stop fueling, close the bleeder valve, and start the vehicle. Check for adequate fuel rail pressure (25+ over tank), to ensure everything is connected in the tank. Then turn off vehicle and resume *Fuel Tank Purging Procedure*.

7. Check the access flange for leaks using an electronic leak detector or leak detection solution.
8. Install the tank cover plate using the *Tank Cover Plate Replacement Procedure*.

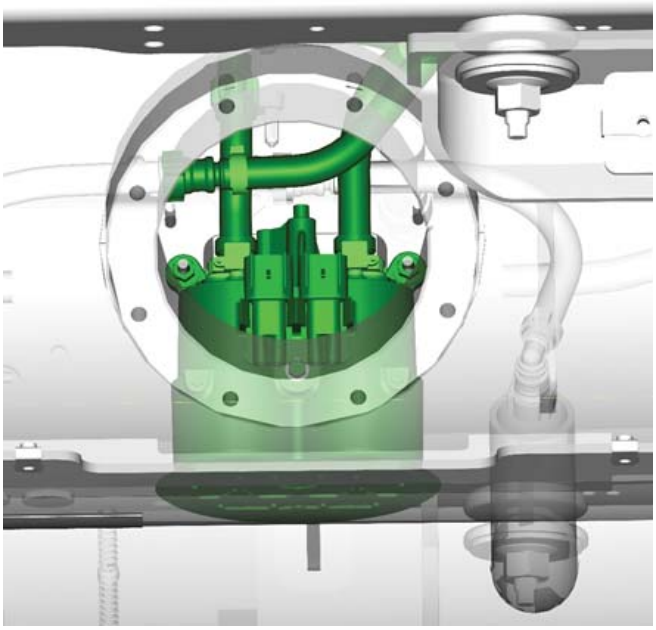

Figure 19 – Fuel Pump Assembly

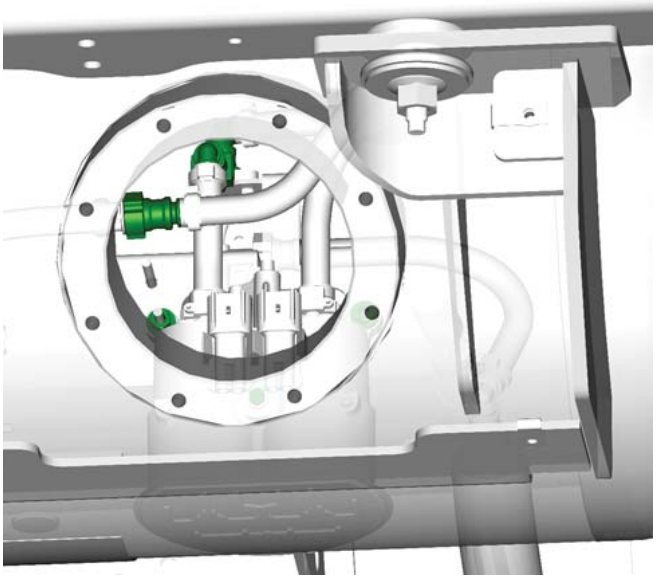

Figure 20 – Fuel Pump Fasteners

Fuel Level Sender Assembly

Description

The fuel level sender measures the liquid level in the fuel tank. It uses a 5V Hall-effect sensor to send a signal to the SRM.

Removal

1. Drain the fuel tank using the *Fuel Tank Draining Procedure*.
2. Disconnect the sender electrical connection.
3. Slowly loosen the four (4) hex screws securing the sender in a cross pattern until the part can move.
4. Remove the four (4) hex screws.
5. Remove the sender from the fuel tank.

Replacement

1. Inspect sender boss on the fuel tank and remove any debris.
2. Apply silicone lubricant to the sender O-ring.
3. Install the sender in the fuel tank with the four (4) hex screws. Hand-tighten the screws.
4. Torque the four (4) screws in a cross pattern to an initial torque of 2.5 Nm (22 in-lb).
5. Torque the four (4) screws in a cross pattern to a final torque of 10 Nm (7.4 ft-lb).
6. Connect the wiring to the sender.
7. Purge the tank using the *Fuel Tank Purging Procedure*.
8. Leak check the sending unit using an electronic leak detector or leak detection solution.

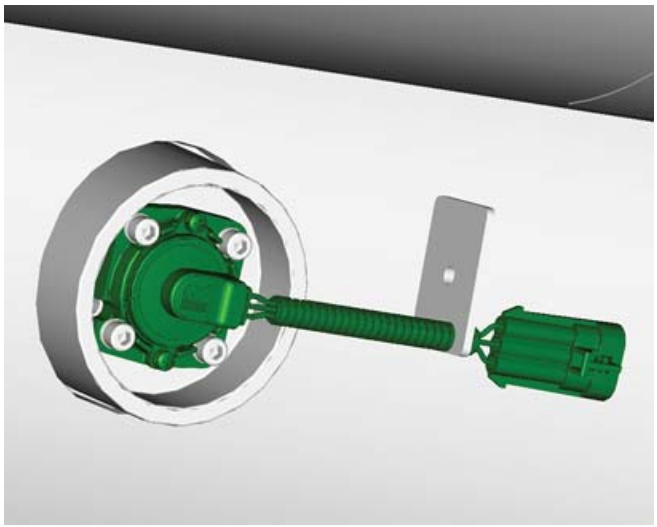

Figure 21 – Sender in Tank

Fuel Level Sender Twinsight

Description

The fuel level sender twinsight is a Hall-effect sensor magnetically connected to the fuel level sender body. It can be replaced independently of the fuel level sender.

Removal

1. Disconnect the fuel level sender electrical connection.
2. Remove the two (2) Phillips-head screws from the fuel level sender twinsight.

⚠ WARNING

Do not loosen the four (4) hex screws. If you need to remove the entire sending unit assembly, follow the *Fuel Level Sender Removal Procedure*.

3. Remove the twinsight from the fuel level sender.

Replacement

1. Using a non-magnetic piece of ferrous metal (such as a screwdriver bit or small socket), move the sender needle to 1/2 by moving it along the back side of the twinsight.
2. Place the twinsight on the fuel level sender body.
3. Install the two (2) Phillips-head screws.
4. Connect the fuel level sender electrical connection.

Figure 22– Twinsight

Tank Pressure Temperature Sensor (TPTS)

Description

The tank pressure temperature sensor is a 5V reference sensor that measures both temperature and pressure in the fuel tank. The output from this sensor can be read using the ROUSH Diagnostic Tool.

Removal

1. Drain the fuel tank using the *Fuel Tank Draining Procedure*.
2. Disconnect the TPTS electrical connection.
3. Remove the TPTS.

Replacement

1. Lubricate the TPTS O-ring using silicone lubricant.

⚠ CAUTION

Do not get lubricant on the sensor element.

2. Install the TPTS in the tank and torque to 7 Nm (5.2 ft-lb).
3. Purge the tank using the *Fuel Tank Purging Procedure*.
4. Leak check the TPTS using an electronic leak detector or leak detection solution.

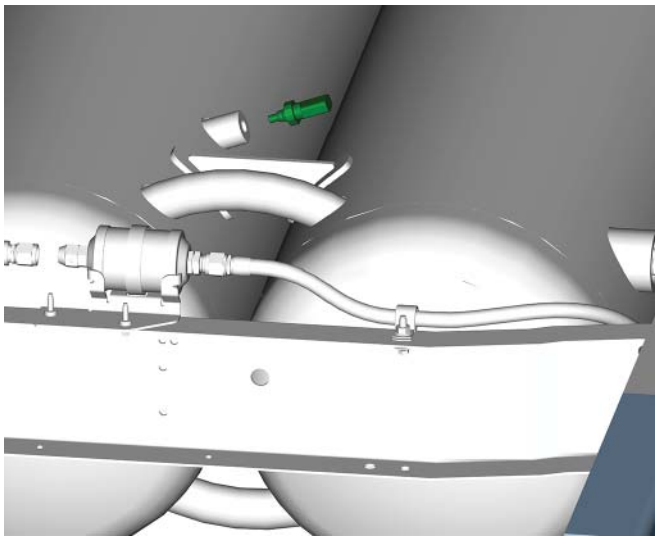

Figure 23 – TPTS

In-Line Supply Filter

Description

The in-line supply filter is located on the inboard side of the left frame rail, forward of the fuel tank. It has a very fine filter element, and filters fuel between the fuel tank and the fuel rails. This filter must be replaced every 50,000 miles. A restricted filter could cause low fuel pressure at the fuel rail.

Removal

1. Depressurize the supply line using the *Fuel Line Purging Procedure*.

NOTE: You can omit the step where you loosen the fitting at the return valve as only the supply line needs to be depressurized.

2. Using two (2) wrenches, slowly loosen the fittings on the in-line supply filter.

3. Loosen the in-line supply filter mounting clamps.
4. Remove the filter from the bracket.

Replacement

1. Install the new filter in the bracket.
2. Tighten the mounting clamps.
3. Install the two (2) fuel lines to the filter and hand-tighten.
4. Counter-brace the filter and torque the inlet line (line between the filter and tank) to 57 Nm (42 ft-lb).
5. Counter-brace the filter and torque the outlet line (line between the filter and FRPCM) to 28 Nm (21 ft-lb).
6. Perform the *Fuel System Priming Procedure*.
7. Leak check the filter and lines using an electronic leak detector or leak detection solution.

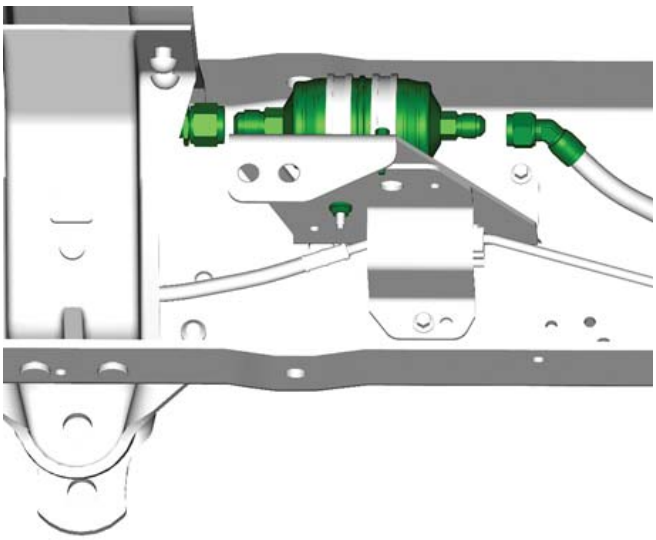

Figure 24 – Supply Line Filter

Fuel Rail

Description

The ROUSH CleanTech fuel rail mounts to the intake manifold and uses ten (10) individual injectors to inject liquid propane.

Removal

1. Purge the fuel lines using the *Fuel Line Purging Procedure*.
2. Disconnect the IPTS electrical connection (left fuel rail only).
3. Disconnect all five (5) fuel injector connections.
4. Disconnect the fuel rail supply and fuel rail return lines from the ends of the fuel rail. Inspect O-rings and replace if damaged.
5. Remove the two (2) bolts connecting the fuel rail to the intake manifold.
6. Lift upward to remove the fuel rail from the intake manifold.

Replacement

1. Lubricate the injector spacer tube O-rings with clean engine oil or silicone O-ring lubricant.
2. Insert the fuel rail into the intake manifold, pushing down firmly to seat the O-rings.
3. Install the two (2) bolts connecting the fuel rail to the intake manifold, torque to 10 Nm (7.4 ft-lb).
4. Connect the fuel rail supply line and fuel rail return line to the fuel rail.
5. Torque line fittings to 21 Nm (15.5 ft-lb).
6. Connect IPTS electrical connector (left fuel rail only).
7. Connect the fuel injector electrical connectors.
8. Perform the *Fuel System Priming Procedure*.
9. Leak check all spacer tubes and fuel lines connections on the fuel rail assembly using an electronic leak detector or leak detection solution.

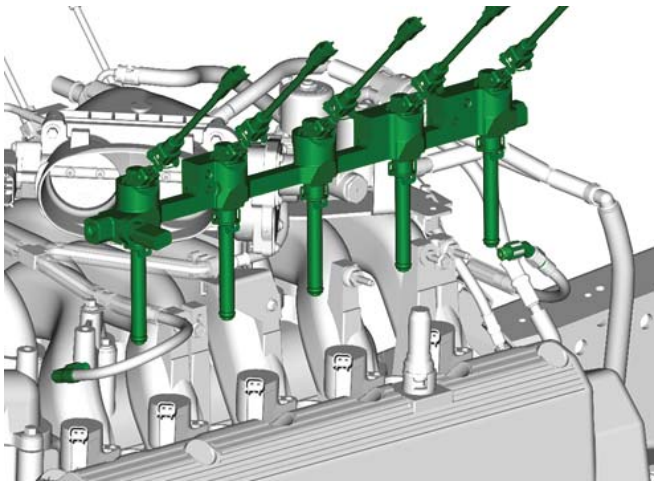

Figure 25 – Fuel Rail

Fuel Injectors

Description

The fuel injectors are mounted in the fuel rail and inject liquid propane into the intake manifold.

Removal

1. Perform the *Fuel Line Purging Procedure*.
2. Disconnect the fuel injector electrical connector.
3. Using snap-ring pliers, remove the C-clip retaining the injector.
4. Pull up firmly on the injector.

Replacement

1. Lubricate the new fuel injector O-ring with clean engine oil or silicone lubricant.
2. Install the injector into the fuel rail, pressing down firmly to fully seat the injector.
3. Install the retaining C-clip.
4. Install the injector electrical connector.
5. Perform the *Fuel System Priming Procedure*.
6. Leak check the injector using an electronic leak detector or leak detection solution.

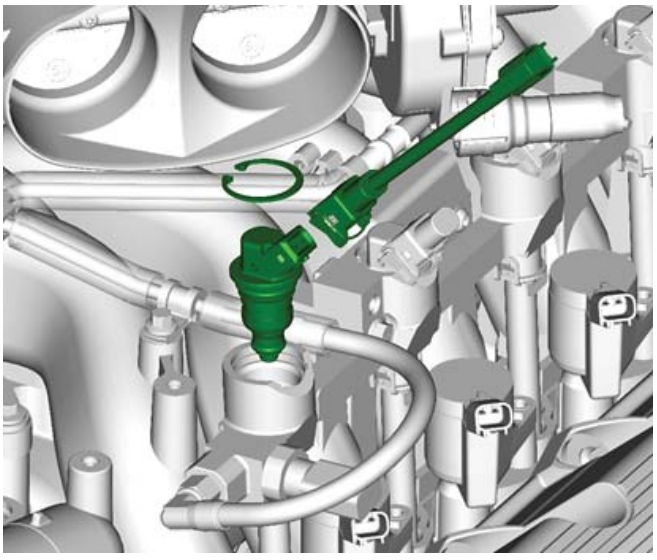

Figure 26 – Injector

Integrated Pressure Temperature Sensor (IPTS)

Description

The IPTS is a 5V reference sensor mounted at the front of the left fuel rail. It measures pressure and temperature of fuel in the rail. The fuel rail pressure and temperature reading is important for the start sequence, injector pulse width, as well as other functions.

Removal

1. Depressurize the fuel rail using the *Fuel Line Purging Procedure*.
2. Disconnect the IPTS electrical connector.
3. Remove the IPTS.

Replacement

1. Install the IPTS.
2. Torque to 7 Nm (5.2 ft-lb).
3. Connect the IPTS electrical connector.
4. Perform the *Fuel System Priming Procedure*.
5. Leak check the IPTS with an electronic leak detector or leak detection solution.

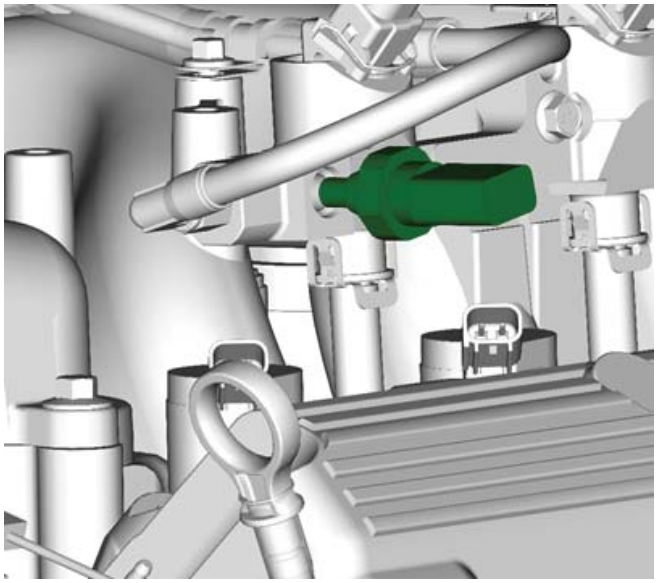

Figure 27 – IPTS

Fuel Rail Pressure Control Module

Description

The FRPCM is a unit consisting of two (2) normally closed solenoids and a return check valve. The FRPCM is controlled directly by the Gateway Module which is governed by the PCM. Included in the FRPCM are:

Supply Solenoid

Open (energized) when the engine is running, the supply solenoid allows fuel to flow from the chassis fuel lines to the fuel rail. The supply solenoid is closed when the engine is turned off, preventing fuel from flowing from the chassis fuel lines to the engine fuel rail.

NOTE: There is a second supply solenoid located at the fuel tank which prevents fuel from flowing into the chassis fuel lines when the engine is turned off.

Return Check Valve

Open when the engine is running, the return check valve allows fuel to return from the fuel rails to the chassis fuel lines. The return check valve closes when the engine is turned off, isolating the fuel return line and fuel tank, and preventing fuel from backfilling the engine fuel rail.

Bleed Solenoid

Closed when the engine is running, the bleed solenoid seals the fuel rail from the vehicle EVAP system. When ambient temperature is above 40°F, after the engine is turned off for approximately one hour, the bleed solenoid opens for a calibrated length of time, allowing all the fuel pressure to bleed from the fuel rail through a metered orifice and into the carbon canister. When the process is complete, the solenoid closes, preventing fuel from entering the EVAP system.

Removal

1. Depressurize the fuel system using the *Fuel Line Purging Procedure*.
2. Disconnect the electrical connector for each FRPCM solenoid. Take note of the connector locations.
3. Remove the fuel lines from the FRPCM.
4. Inspect fuel line O-rings and replace if damaged.
5. Remove the vapor line by squeezing the release tabs on either side of the connector.
6. Remove the two (2) fasteners securing the FRPCM to the bracket.

Replacement

1. Install the FRPCM to the bracket and torque fasteners to 10 Nm (7.4 ft-lb).
2. Install fuel lines starting with the line closest to the bleed port, working forward.

Torque specifications:

   a. Forward return line: 19 Nm (14 ft-lb)
   b. Fuel rail supply line: 24.5 Nm (18 ft-lb)
   c. Forward supply line: 31 Nm (23 ft-lb)
   d. Fuel rail return line: 21 Nm (15.5 ft-lb)

3. Connect the wiring harness wiring connectors. Ensure correct connector locations or vehicle will not start.
4. Connect the vapor line.
5. Perform the *Fuel System Priming Procedure*.
6. Leak check all FRPCM connection using an electronic leak detector or leak detection solution.

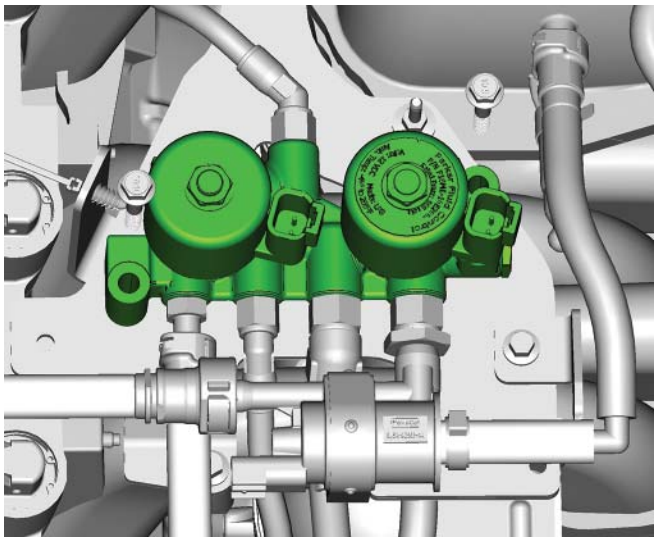

Figure 28 – FRPCM

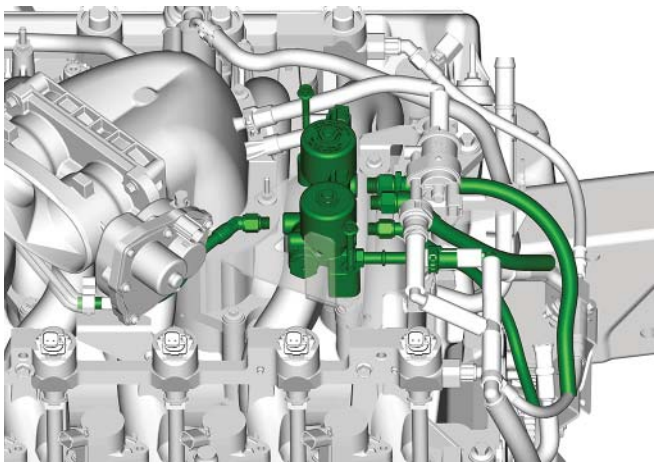

Figure 29 – FRPCM

FRPCM Bleed Port

Description

The FRPCM bleed port meters the rate that the bleed solenoid can depressurize the fuel rails after engine shutdown.

Removal

1. Remove the vapor line connecting to the FRPCM bleed port by squeezing the release tabs on either side of the connector.
2. Remove the FRPCM bleed port.

Replacement

1. Install the FRPCM bleed port and torque to 19 Nm (14 ft-lb).
2. Install the vapor line to the FRPCM bleed port.

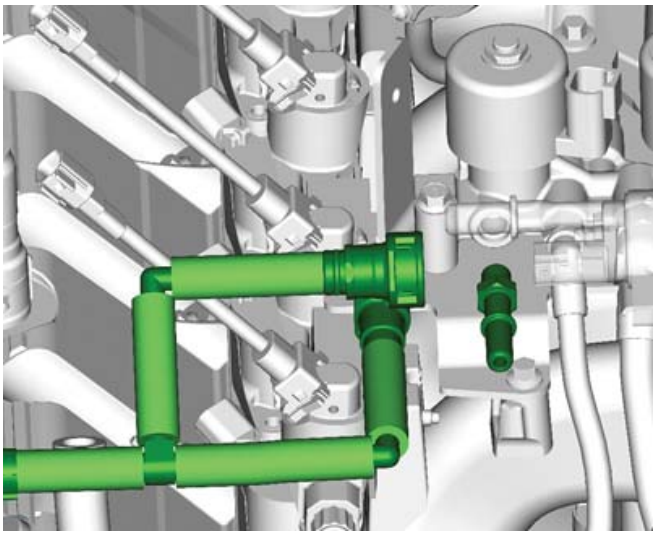

Figure 30 – FRPCM Bleed Port

Smart Relay Module (SRM)

Description

The SRM is an electronic control module that provides additional input/output features required for the LPA fuel system via the vehicle's controller area network (CAN) bus. The module is installed on the left front inner fender panel.

Removal

1. Disconnect the negative battery cable.
2. Note SRM orientation on bracket.
3. Disconnect the SRM electrical connector by pressing down the front tab, then pulling up on the connector lock and moving it to the other side of the connector. Carefully move the connector side-to-side when removing. Note connector orientation.
4. Remove the four (4) fasteners securing the SRM to the bracket and remove the SRM.

Replacement

1. Place the SRM on the bracket as shown, checking for orientation.
2. Install the four (4) mounting fasteners and torque to 10 Nm (7.4 ft-lb).
3. Carefully install the SRM electrical connector and lock the connector lock.
4. Reconnect the battery.

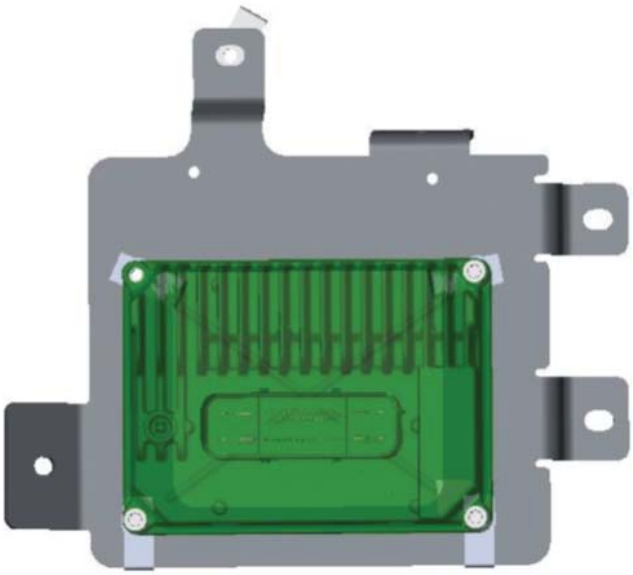

Figure 31 – SRM