LIQUID PROPANE INJECTION SYSTEM DESCRIPTION AND OPERATION

The Liquid Propane Injection system works the same as a gasoline fuel injection system with the exception it injects propane in a liquid state into the intake port.

The LPI® system consists of three main components: the tank assembly, the fuel lines and the injectors. The tank is located on the vehicle frame and the lines are routed forward to the engine compartment injector rail assemblies. They are mounted in the same location as a set of gasoline injector rails would be installed. The fuel tank contains the most complicated components of the LPI® system. It includes an internal electric fuel pump, fuel supply, return and bypass valves, and a baffle that keeps the pump submerged in liquid propane. It also has a fuel level float assembly, pressure relief valve, overfill prevention device, and both liquid and vapor service valves. The LPI® fuel pump increases or boosts the tank pressure by 50–60 psi. The fuel is supplied to the injectors then loops back to the return valve on the tank. This return valve is integrated with a regulator inside the tank. The regulator maintains the fuel pump boost pressure between 50 to 60 PSI. This allows there to be a pocket of liquid supplying the injectors at all times. Regardless of the propane tank internal pressure, the pump boost pressure remains constant. This is how the fuel remains liquid throughout the supply section of the system. When the engine is turned off heat soak increases the pressure inside the rails causing the liquid to vaporize and rapidly flow back to the tank. To help with hot restarts, the system goes through a purge cycle that will vary, depending on temperature and pressure in the LPI® rails. With every start up the system activates a bypass solenoid valve which opens a larger return passage allowing the fuel rails to be purged rapidly with liquid propane. This strategy is built into the system’s LPG control module. During the purge cycle the “Wait to Start” indicator will be illuminated.
Figure 2 LPI® Fuel System Mechanization/Hydraulic Diagram
LPG Fuel Tanks

The fuel tanks meet American Society of Mechanical Engineers (ASME) design for a working pressure of 312.5 psi and a burst pressure of 1250 psi. Baffles are built into the tank to keep the fuel pump submerged in liquid propane.

Overfilling Prevention Device (OPD) (Figure 3)

By code, tanks must not be filled tanks more than 80% full. The overfilling prevention device is a mechanical float-actuated valve that stops the tank from being filled more than 80% capacity. This is to allow room for the liquid propane to expand.

Fixed Liquid level Gauge (80% Bleeder) (Figure 4)

The fixed liquid level gauge is a mechanical means of verifying when the propane tank reaches 80% capacity which is the maximum liquid capacity of any propane tank. This gauge is a bleeder opened by a small thumb wheel that can be used for visual monitoring during filling. When a white mist appears exiting this bleeder the tank is at 80% liquid capacity and the fill process should be stopped and the bleeder closed. Use of the 80% bleed valve is not recommended when refueling the vehicle. Because the tank is equipped with an OPD, the 80% bleed valve is not required to be used each time the tank is filled. However, many fill station attendants prefer to utilize it during the fill process. There are also fill stations where bleeding fuel to the atmosphere is prohibited. CAUTION: If this bleeder is utilized propane exits the valve and when mixed with air, the area around the filling operation can become a flammable/combustible environment. Follow proper filling procedures when filling a propane tank.

Pressure Relief Valve (Figure 4)

If the pressure in the fuel tank exceeds 312.5 psi, the pressure relief valve (PRV) will vent propane vapor to the atmosphere. The pressure will not get this high unless the tank has been overfilled, or unless the tank is hotter than 60°C (140°F) or both. When the PRV vents the sudden pressure drop significantly cools the remaining liquid, the boiling liquid propane absorbs heat, pressure drops and the valve closes.
Liquid Supply Valve (Figure 3)

The liquid supply valve delivers liquid pressurized by the fuel pump thru the fuel lines to the injector rails. The valve is excess flow protected and is integrated with an external 12 volt operated solenoid. It is activated when the ignition key is cycled to the on position. It is controlled by the OEM fuel pump control strategy. The electric solenoid serves as a 100% fuel lock-off for safety.

Regulated Vapor Return Valve (Figure 3)

The liquid fuel is circulated from the fuel pump through the liquid supply valve, fuel lines, and injector rails and back to the tank via the return valve. This return valve is a manual valve and the fuel returns to the tank through a regulator and a balancing orifice internal to the vapor space of the tank. This valve is equipped with an internal hydrostatic line pressure relief device if the manual valve is closed.

By-pass Vapor Valve (Figure 3)

This normally closed valve opens when the LPG control module energizes the LPG bypass relay. When energized, the fuel bypasses the fuel pressure regulator and flows directly into the fuel tank. This reduces the time required to purge all vapor from the system during start up. The LPG bypass solenoid has a built in excess flow valve that will reduce the flow of LPG if the pressure difference between the inlet and outlet of the valve is greater than the calibrated amount. There is also a manual shut-off valve integrated into the LPG bypass solenoid valve. This manual valve must be opened for the by-pass function to work correctly.

Fuel Pump Wire Pass-Thru (Figure 3)

These two wires provide 12V and ground to the fuel pump through this hi-pressure sealed plug. The wires are sealed and molded into the pipe fitting without any added connections or terminals to increase resistance.

Fuel Level Float / Sensor (Figure 3)

Externally mounted, an arm and float extends to the inside of the tank. It raises or lowers with the liquid level of the fuel. An externally mounted sending unit reacts magnetically to the fuel level and provides a resistance value to the fuel level gauge on the dash. Resistance value is 250 ohms empty to 40 ohms full.

Liquid Evacuation Service Valve (Figure 3)

This valve is used to evacuate the fuel from the tank before servicing any valve on the tank or the tank itself. The valve is capped with a brass cap which should always be reinstalled after any service procedure.

Fuel Pump Access Cover (Figure 4)

This port is used to provide access to the fuel pump inside the tank. The fuel pump access cover utilizes an o-ring seal to seal to the flange. This O-ring should be replaced anytime it is removed.
Internal Fuel Tank

Fuel Pump (Figure 5)

The LPI® system is equipped with a submerged fuel pump located in the bottom of the propane tank much like a submerged gasoline fuel pump. In order to keep the fuel a liquid throughout the fuel lines and injectors the fuel pump will boost pressure to approximately 50 - 60 PSI over tank pressure.

Baffle Check Valve (Figure 5)

A one way check valve is used to allow fuel to flow into the baffled area freely, thus submerging the fuel pump in liquid propane. The baffle check valve will not allow fuel to escape out from outside the baffled area.

WARNING

Do not remove any valves or fittings from the tank unless the tank had been evacuated completely. The pressure inside a propane tank can push a valve or fitting out with enough force to cause death, injury or property damage.
FILTRATION AND FUEL LINES

Fill Filter / Supply Filters (Figures 6-8)

It is necessary as with any fuel to filter contaminants from entering the system. The liquid propane injection system incorporates a fill filter to catch contaminants from entering the tank during refueling. This alone will prevent most contamination from entering the fuel system however our filtration continues as with a gasoline system utilizing a “sock” type filter screen on the fuel pump and another inline fuel filter, located on the frame rail in the fuel supply line, to catch any finite particles before the fuel reaches the injectors. The fill filter and the inline fuel filter are replaceable and recommended replacement interval is 30,000 miles. When replacing the filters follow the fuel evacuation procedures. Refer to Fuel Line Draining.

LPG FUEL LINES (Figure 8)

Fuel lines are Type III LPG approved hoses with minimum permeability in order to pass the evaporative shed test required by EPA/CARB. These hoses are very robust with rubber coated stainless steel braiding to protect against chaffing while built to a design working pressure of 350 PSI and burst pressure of 1,750 PSI. The lines are installed not to impinge on any sharp edges of the vehicle, engine or transmission components and are routed on the vehicle chassis.
utilities a “wait to start light” that illuminates for the duration of the pump priming. It is recommended to follow the “wait to start light” procedure to start the engine without the risk of a failed start. If the engine is started before the purge of vapor and the wait to start light goes out, a rough idle may be experienced.

Figure 9 Fuel Distribution System

LPI® Fuel Rails (Figure 10)
The fuel rails are built of billet aluminum for minimum heat transfer and to accommodate the fuel distribution to each injector. The liquid fuel is delivered to each injector through a dedicated supply passage while a separate return passage allows for the fuel to flow back to the tank with minimum restriction. While the engine is running the fuel flows through the rails and back to the tank generally in a liquid state. However, the absorption of heat from the engine and some restriction in the return passage can cause production of vapor bubbles which are returned to the tank and condense back to liquid. Once the engine has been turned off the absorption of heat into the rails will vaporize the liquid fuel increasing the pressure in the rail which pushes the liquid back to the tank until temperature and pressure is equal to the tank. This leaves a void of vapor “a vapor lock” in the injector rails. Therefore the pump must prime the system before the engine is started. The LPI® system

Figure 10 LPG Fuel Flow in the Injector Rails

LPI® Fuel Injector (Figure 11-13)
The injectors are high quality automotive injectors manufactured by Siemens VDO which is now Continental AG. The injectors are very reliable unless subjected to fuel contamination, such as water. When water is present in large amounts, freezing could occur causing random misfires. Other contaminants such as rust particles sulfur or brine (salt) could restrict the injector orifice. The fuel injectors are a bottom feed design and the high impedance operating coil electrically match the resistance of most gasoline injector controllers at 12-13 Ω ohms. Flow calibrations are sized to meet the application. The spray pattern is commonly referred to as “pencil stream” and as liquid propane flows out of the injector orifice it immediately starts to vaporize.
8.0 Liter LPG Fuel System Description and Operation

Pressure Temperature Sensor (Figure 14 & 16)

The combination LPG pressure and temperature sensor is located on the driver’s side fuel rail. The LPG control module provides a reference voltage and ground to the sensor and receives the fuel pressure and temperature signals from the combination sensor. The values are used to calculate the amount of purge time required for startup.
Fuel Distribution Blocks (Figure 15 & 16)

The LPI® system fuel distribution blocks are located behind the intake manifold. There is a supply block and return block. The fuel passes into the supply block from the tank and distributes fuel equally to each rail, then once the fuel exits the other side of both rails it is then returned to the return block and sent back to the tank.

Figure 15 LPG Fuel Distribution Block

Stainless Steel Fuel Lines (Figure 17)

The fuel lines going from the distribution block to the rails is made out of 1/4" OD 316 stainless steel. We incorporate a double flare for each connection which gives added protection against leaks. The max rated working pressure is 4300 PSI which is well over the 350 Max PSI needed for running the LPI® System.
Evaporative Emissions System  
(Figure 18)

For many years gaseous fueled vehicles were exempt from evaporative emissions however after re-visiting the facts and conducting some testing; the requirements of EPA/CARB have identified that propane vehicles do need to pass evaporative emissions tests. There are difficulties in the doing this, especially with “vapor style” propane systems due to the fact that hoses are permeable, diaphragms are permeable and injectors do leak. Actually gasoline injectors leak and additional “EVAP” considerations are made on some gasoline vehicles instead of the usual handling of the vapors in the gasoline storage tank. With a propane vehicle the fuel storage tank is a closed system containing a pressurized fuel where control of fuel vapors is not necessary although any small leak from a fitting, a hose or an injector can cause failed test results over a 72 hour “shed test.” The LPI® system has been designed to minimize any possibilities of leaks by using TYPE III hoses, stainless steel fuel supply tubes, reducing the amount of openings in the tank, utilizing environmental friendly thread sealing compounds and using no external regulator or vaporizer. The injectors however have a specified minimum leak rate and after mileage accumulation the leak rate may increase. This does not the affect performance of fuel control. Therefore a proprietary designed EVAP fuel vapor handling system was implemented to assure compliance with regulations.

The LPI® system utilizes the OEM carbon canister and canister purge solenoid as well as the addition of a vacuum pump, to take care of any injector leakage while the engine is not running. This accomplishes two goals, it eliminates the possibility of fuel vapor leaking to the atmosphere and eliminates the chance of a richer fuel mixture during start up; both of which could cause non-compliance of tailpipe emissions or evaporative emissions.

While the vehicle is parked a low amperage vacuum pump evacuates the manifold on command by the LPG Control Module. The pump may be heard while the vehicle is parked as it comes on at specific intervals. Once the vehicle is re-started, the OEM canister purge strategy is utilized to purge the carbon canisters. The process starts over again when the vehicle is turned off.
Figure 19 LPG Evaporative Canister Routing