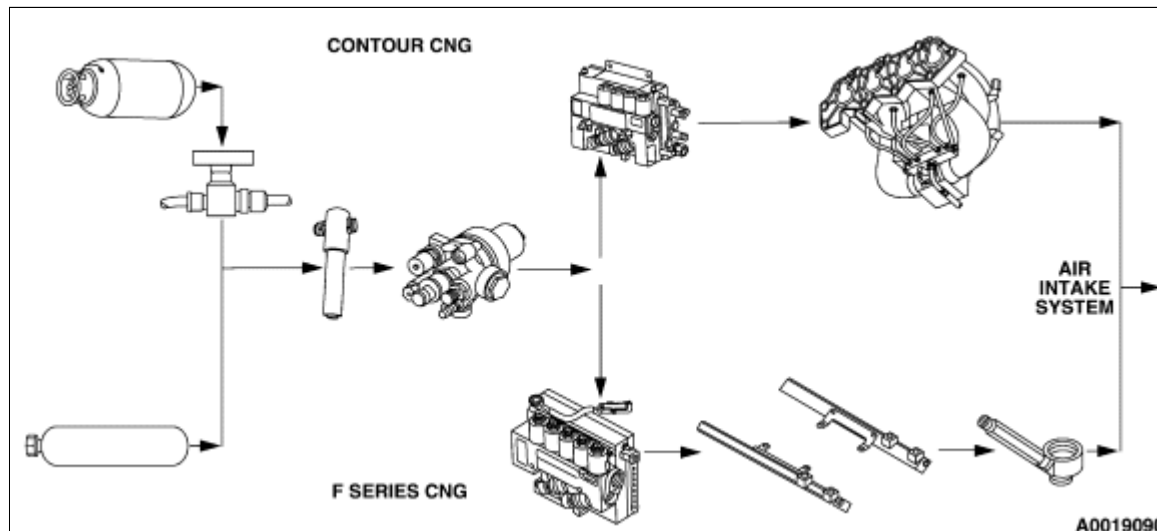


## Fuel System

The alternative fuel system consists of CNG or LPG fuel tanks, a fuel filter, an LPG vaporizer/regulator, a CNG high pressure regulator, a combined metering valve and sensor assembly called a Compuvalve, fuel shutoff solenoids (LPG), an alternative fuel control module (AFCM), a manual fuel shutoff valve (CNG Contour), a gaseous fuel distribution manifold (Contour), an adjustable tuning tee, fuel rails, fuel injector sleeves, an ALT/GAS switch, an ALT/GAS switch light and an ALT fuel relay module.

### Compressed Natural Gas (CNG) System

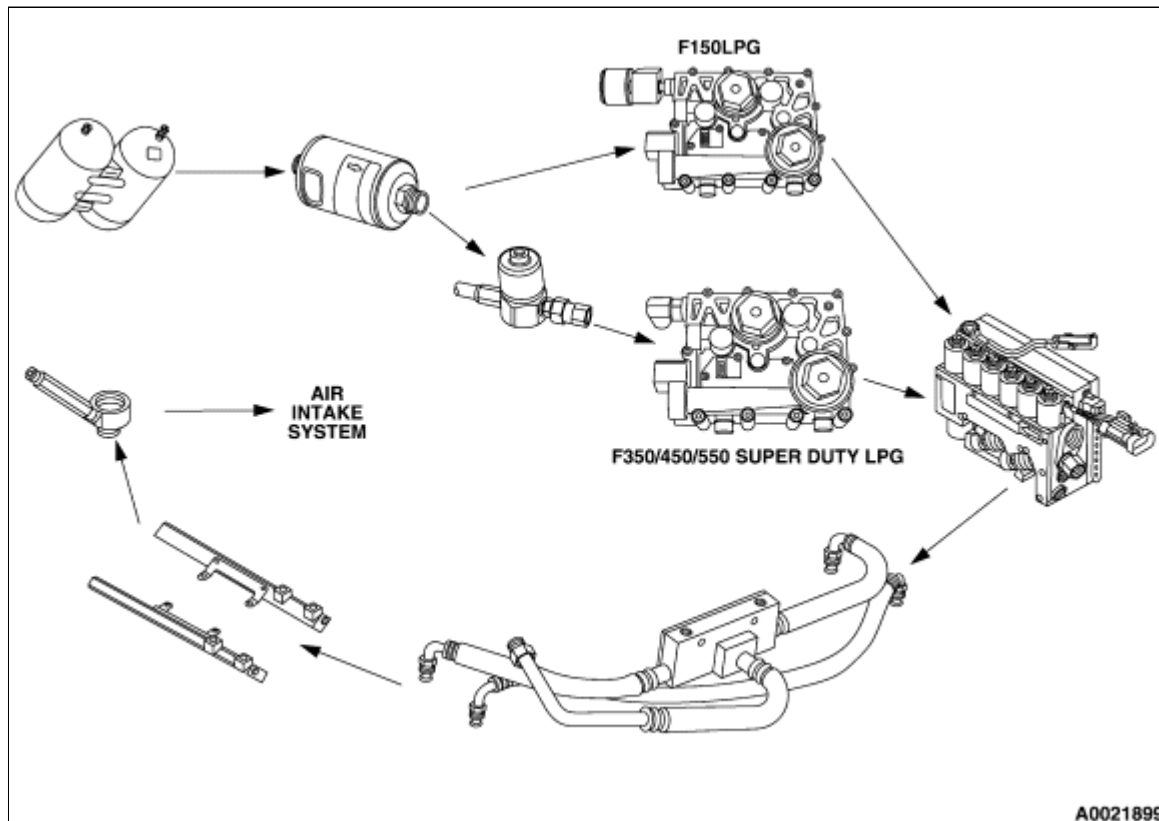
Fuel from the compressed natural gas (CNG) fuel tanks flows through the fuel tank lockoff valves, the manual fuel shutoff valve (Contour) high pressure shutoff valve (F150) and coalescent fuel filter to the gas regulator. The gas regulator provides a consistent system operating fuel pressure of approximately 100 psig. The fuel is passed to the Compuvalve. The Compuvalve meters fuel according to demand, calculates spark advance for maximum power, and registers fuel storage pressure on the gasoline fuel gauge when in ALT mode. A combination of sensors and inputs from the are used to monitor the engine and environment to provide closed loop control of fuel. Through speed density calculations, the Compuvalve determines fuel flow and air flow while adjusting the air/fuel mixture using internal injector valves. An air/fuel adjustment is made for each spark event. The fuel is then introduced into the gaseous fuel distribution manifold (Contour) or fuel rails (F-Series) and to the intake air system through the fuel injector sleeve assembly (F-Series).



### Liquefied Petroleum Gas (LPG) System (F150 5.4L V8 and F350/450/550 6.8L VID)

Liquid propane from the liquefied petroleum gas (LPG) fuel tank flows through the manual shutoff valve through the fuel filter to the lock-off solenoid, before or in, the vaporizer (F-150). When the lock-off solenoid is open, liquid propane flows into the vaporizer heat exchanger. Heat from the engine coolant is used to convert the liquid fuel to gas. When engine coolant is below 0°C (32°F), a cold start heater is used to provide heat to the heat exchanger of the vaporizer. The vaporizer provides gaseous propane at a consistent operating pressure to the Compuvalve. The Compuvalve meters fuel according to demand and calculates spark advance for maximum power and driveability. A combination of sensors and inputs from the powertrain control module (PCM) are used to monitor the engine and the environment to provide closed loop control of fuel. The Compuvalve directs fuel through the low pressure hose to an adjustable tuning tee,

through the fuel rail assemblies and is introduced into the intake system through fuel injector sleeve assemblies.



## Alternative Fuel Tank

The CNG and LPG fuel tanks are refillable storage tanks requiring replacement only when damaged or upon failing an inspection. Both the CNG and LPG tanks are equipped with a non-serviceable pressure relief device (PRD). A safety valve designed to relieve all fuel pressure within the alternative fuel tank, if exposed to fire (tank replacement is required once the PRD safety valve has been released). The CNG tank construction consists of a metal liner reinforced with a resin impregnated continuous filament shell, whereas the LPG tank is of a welded steel construction. Both tank types are refueled through use of a fuel fill valve (located behind the fuel filler door) containing a safety valve that only allows one-way fuel flow to the tanks (the F-Series CNG can be vented through the fill valve). The CNG and LPG fuel tanks are connected to the fill valve by a steel high-pressure line (used on the Contour) or by a high-pressure hose.

The Contour has a single CNG tank having an operating pressure rating of 3000 psi with dual bracket mounting in the rear luggage area just behind the rear seat backrest.

The F-Series is supplied with either single or dual CNG or LPG tank configuration, which are bolted inside the forward area of the bed floor (may be mounted underneath rear bed on flat bed vehicles).

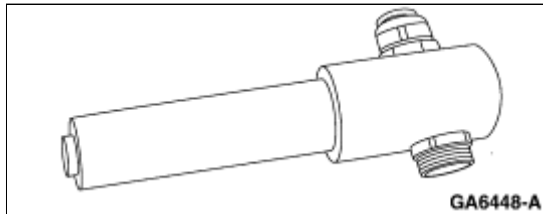
The LPG dual tank configuration uses hollow support tubes welded to both tanks that also serve as crossover tubes.

The CNG fuel tank used with the F-150 has an operating pressure rating of 3,600 psi. The LPG fuel tank is fitted with an 80% outage valve (used when refueling), an 80% auto stop/fill valve and an internal float device used to monitor the fuel level.

The F-Super Duty 350/450/550 is supplied with an LPG tank mounted to the LH frame rail behind the cab. An optional tank location is behind the rear axle.

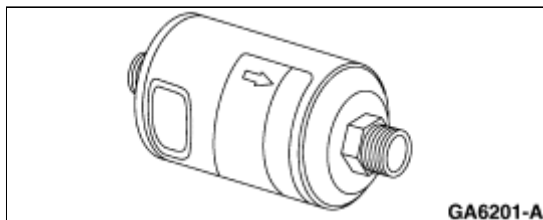
### Coalescent Fuel Filter (CNG)

The coalescent fuel filter removes water and particulate contamination from the CNG fuel system. The fuel filter housing has a drain plug allowing water to be drained during scheduled maintenance.



### Fuel Filter (LPG)

The fuel filter removes water and particulate contamination from the LPG fuel system. LPG fuel travels through this filter in a liquid state.

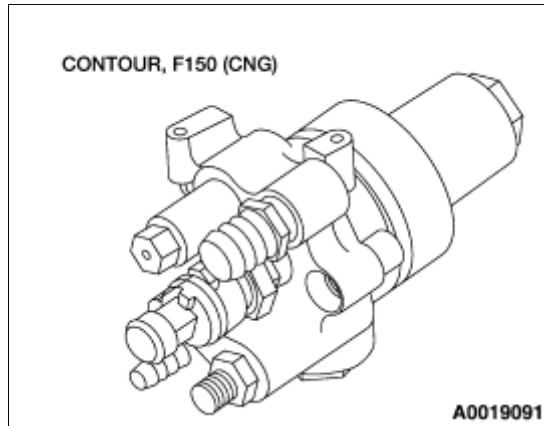


### Fuel Injector Valves

When in CNG or LPG mode, the Compuvalve instructs the powertrain control module (PCM) to shut off the gasoline fuel injectors and shuts off the gasoline fuel pump through the ALT fuel relay module. The Compuvalve houses two types of injectors. The metal cased injectors are "high flow" and deliver fuel during cruise and acceleration. These are strictly on/off devices. The plastic cased injectors provide idle and trimming flow. These "low flow" injectors are pulse width modulated as required. The fuel is delivered to the intake manifold via fuel injector sleeves (F-Series) or a modified intake manifold (Contour).

### Gas Regulator (CNG)

High pressure CNG enters the high pressure regulator. The gas regulator delivers fuel at 100 psi to the Compuvalve.



## Vaporizer (LPG)

Liquid propane enters the vaporizer and is then heated to a gaseous state. The gaseous fuel is released to the Compuvalve at 40 psia for engine coolant temperatures greater than or equal to 25°C (77°F). Below this temperature, delivery pressure decreases with reduction of engine coolant temperature to a minimum of 32 psia at 0°C (32°F), optimizing vaporization capacity.

### F-150

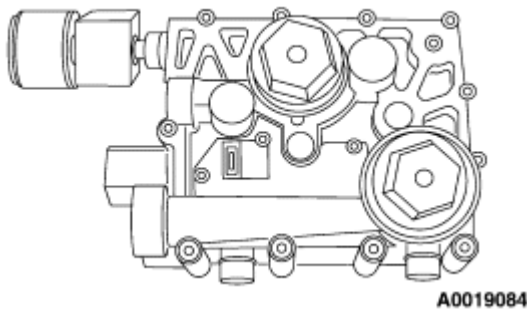


Figure 3.

### F-350/450/550 Super Duty

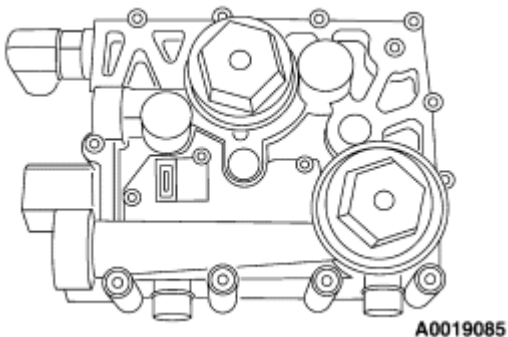
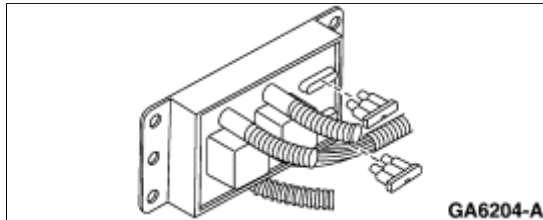


Figure 4.

## ALT Fuel Relay Module

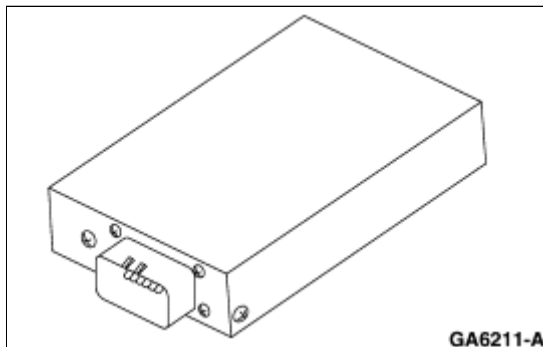
The ALT fuel relay module contains two replaceable fuses. Fuse 1 (3A) protects the battery feed (BATT) to the Compuvalve and Fuse 2 (10A) protects the BATT to the ALT fuel power relay, in turn protecting the VPWR circuits of the Compuvalve. The ALT fuel relay module also contains two dual mini ISO relays: the ALT fuel power relay and the fuel pump cutoff relay. The ALT fuel power relay provides power to the Compuvalve when the key is in the ON position. The fuel pump cutoff relay interrupts the power to the gasoline fuel pump from the base gasoline fuel pump relay when the ALT/GAS switch is placed in the ALT position.



## Alternative Fuel Control Module (AFCM)

### Contour

The alternative fuel control module (AFCM) allows communication between the Compuvalve and the powertrain control module (PCM). The AFCM communicates desired operating mode, ALT or GAS, to the PCM. This allows information to be shared between modules and facilitates troubleshooting. When ALT mode is selected and operating conditions are satisfactory, the Compuvalve, through the AFCM, signals the PCM to turn off the gasoline fuel injectors. During alternative fuel operation, if the fuel source drops below a specified amount, the Compuvalve through the AFCM signals the PCM to turn on the gasoline fuel injectors while the Compuvalve shuts off alternative fuel. This allows smooth switching of fuel systems.



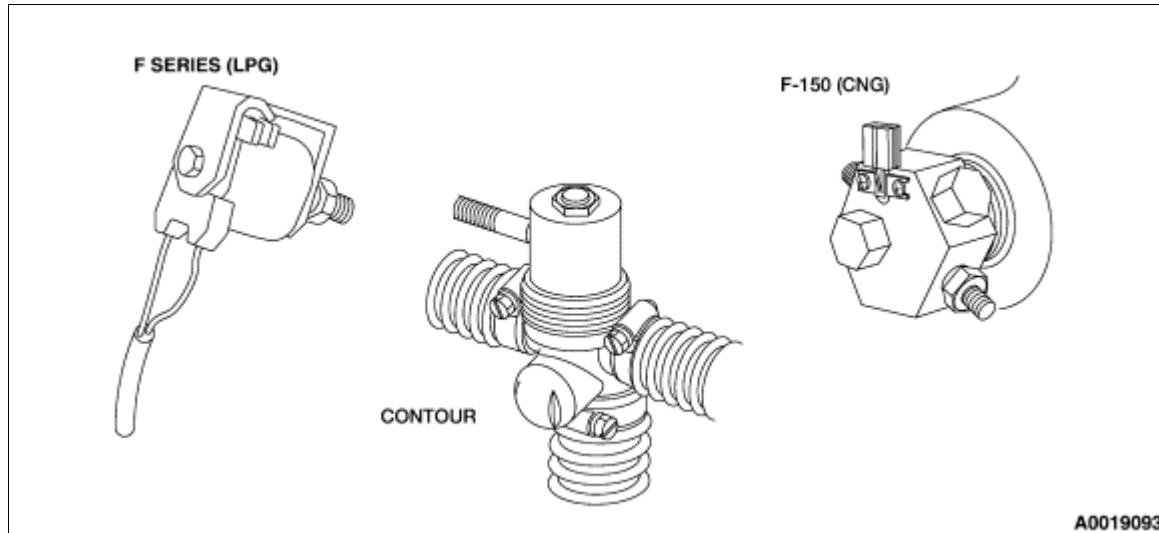
### F-Series

The AFCM is incorporated within the Compuvalve and the fuel system control strategy is identical to Contour.

## Solenoid Tank Valves (CNG)

The tank valve solenoid receives VPWR from the inertia fuel shutoff (IFS) switch. If the IFS is tripped for any reason (i.e. accident), or if the key is on and there is no tach signal received, the tank valve will be closed.

In the event that the ALT fuel system auto switches to base gasoline mode, the tank valves will close. This is triggered when the FRPREAB drops to 45 psia. Only one solenoid tank valve is opened when selecting either ALT position of the three-position ALT/GAS switch when the ignition key is in the ON or crank position. (P131 with dual LPG tank configuration).



### Solenoid Lockoff Valve (LPG F-Series)

The lockoff solenoid valve is similar to the solenoid tank valve in operation. The lockoff solenoid valve is positioned close to the vaporizer regulates fuel flow into the vaporizer inlet.

### Solenoid Lockoff Valve F-150 (LPG)

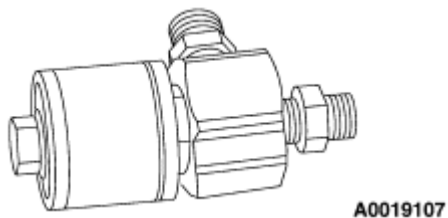


Figure 5.

### Solenoid Lockoff Valve F-350/450/550 Super Duty

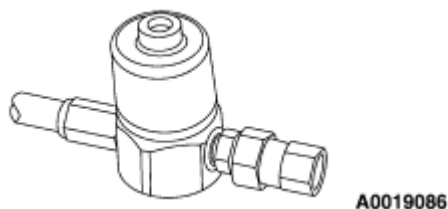
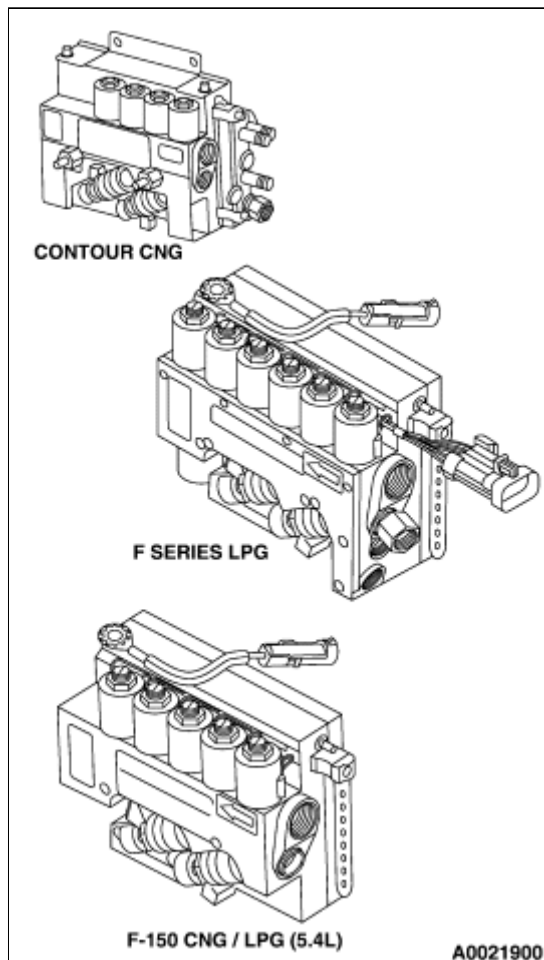


Figure 6.

## Compuvalve

### Contour

The Compuvalve electronically meters fuel according to demand and calculates spark advance for optimum driveability and emissions. A combination of sensors and inputs are used to dynamically monitor the engine operating environment. Fuel is delivered through the low pressure hose into the fuel rails (F-Series) and through the injector sleeves (F-Series) or a modified intake manifold (Contour). Internal to the Compuvalve are the fuel absolute pressure (FAP) sensor, the fuel rail temperature (FRT) sensor, and the manifold absolute pressure (MAP) sensor. The Compuvalve intercepts the base vehicle fuel gauge signal and substitutes a signal from a float style sensor in the alternative fuel tank (LPG) or a fuel tank pressure sensor mounted on the high pressure regulator (CNG). This allows the Compuvalve to display the alternative fuel level on the gasoline fuel gauge while in ALT mode.



### F-Series

The alternative fuel control module (AFCM) is incorporated within the Compuvalve. The fuel system control strategy is identical to Contour.

### Fuel Level Float (LPG)

A float style fuel level sending unit is mounted in the alternative fuel tank. The Compuvalve receives input from the fuel level float, interrupts the signal from the base vehicle fuel gauge signal and sends a pulse width modulated signal to the base gasoline fuel gauge representing the level of liquid propane.

### **Cold Start Heater (LPG)**

The cold start heater is integral to the vaporizer/regulator. When engine coolant is below 0°C (32°F) the cold start heater turns on and turns off when engine coolant reaches 10°C (50 °F). The cold start heater is used to provide heat to the heat exchanger in the vaporizer.

### **Cold Start Heater Relay (LPG)**

The cold start heater is controlled by the Compuvalve via the cold start relay.

### **Dash Reset Relay (Contour, F-Super Duty 350/450/550)**

The dash reset relay allows for more accurate display of fuel level when switching from one fuel source to the other. Use of the dash reset relay prevents fuel gauge floating, incorrect level reading or slow fuel gauge response.

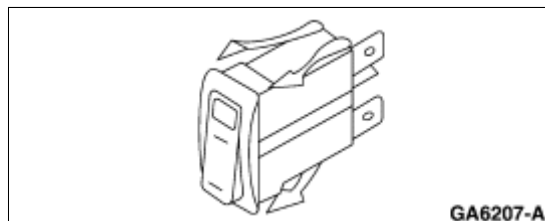
### **Tank Valve Select Relay and LPG Level Sender Select Relay**

**(F-350/450/550 Super Duty dual LPG tank option only)**

The tank valve select relay and the LPG level sender select relay are controlled simultaneously and are used to toggle power to either LPG tank one or to LPG tank two when the ALT fuel system is in operation. Both relays default power to LPG tank one until the dual ALT/GAS switch is in the secondary ALT position. The ALT/GAS switch then provides power to energize both relay coils. When the relay coils are energized power is disconnected from LPG tank one and switched to LPG tank two. The tank valve select relay toggles system power between the LPG tank lock off valve while the LPG level sender select relay toggles between the LPG tank fuel level sender return circuits connecting one or the other to the Compuvalve input.

### **ALT/GAS Switch, ALT/GAS Switch Light**

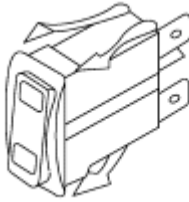
The ALT/GAS switch sends a signal to the Compuvalve requesting ALT fuel mode, when placed in the ALT position. If no signal is received by the Compuvalve, the system defaults to base gasoline mode. The ALT/GAS switch light is incorporated into the ALT/GAS switch. It is controlled by the Compuvalve and is illuminated when operating in ALT/FUEL mode. If an emission-critical diagnostic trouble code (DTC) is recorded, the ALT/GAS switch light will change from a steady on to an irregular flashing condition. If a communication fault arises the indicator will flash with a steady pulse. Once the key is switched to ON, the switch will not change the fuel operating mode.



The dual tank configuration used on F-Super Duty 350/450/550 (if equipped) utilizes a three-position switch for selecting each of the fuel tanks individually (Petrol, LPG tank one or LPG tank two) and is designed with



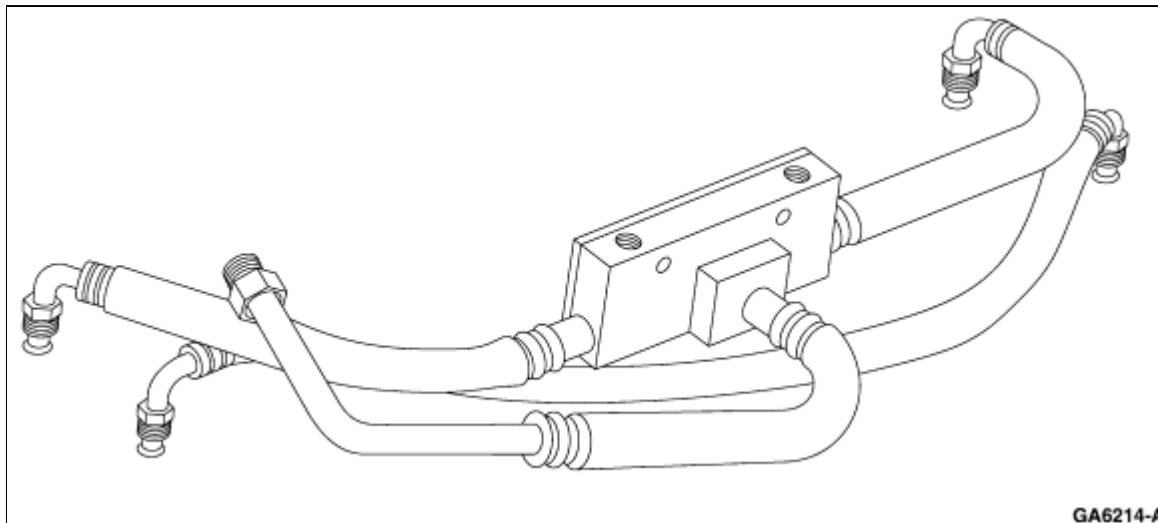
two separate ALT lights indicating which LPG tank is in use when illuminated. System operation with the three-position switch is identical to the two-position switch.



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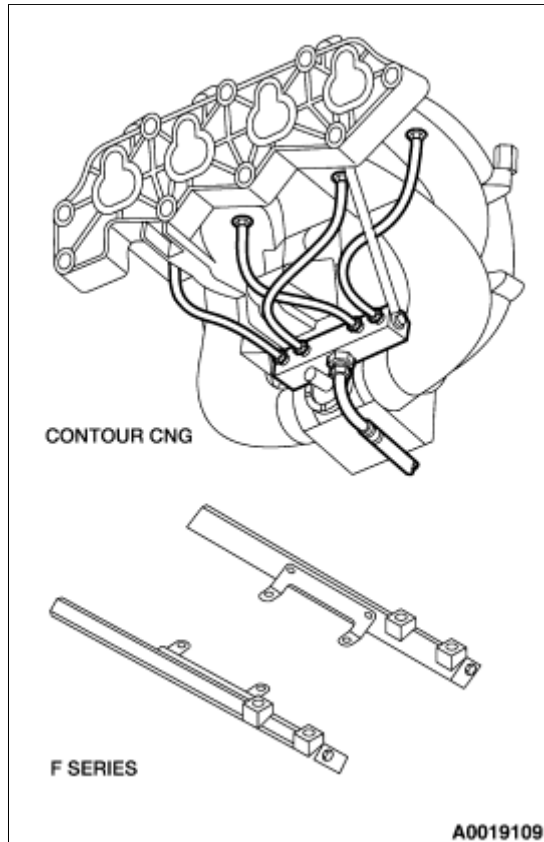
### Adjustable Tuning Tee (F-Series)

The adjustable tuning tee allows a proportioned percentage of the fuel flow to each of the fuel rails. There are two individual adjustment screws, one for each of the two output fuel lines.



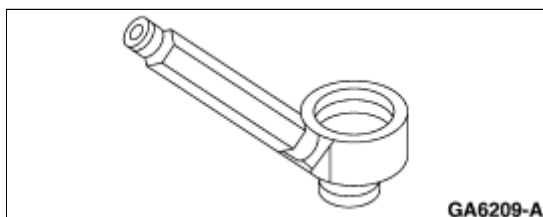
### Fuel Rail

The fuel rails route alternative fuel from the Compuvalve to the base vehicle intake runners.



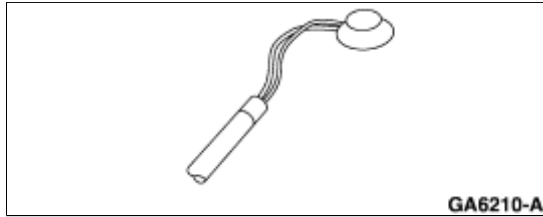
### Injector Sleeves (F-Series)

The injector sleeves are placed in the injector seats. The gasoline fuel injectors are placed in the injector sleeve seats. The sleeves bypass the gasoline fuel injectors, delivering alternative fuel into the intake system and provide a path of fuel flow from the gasoline injectors.



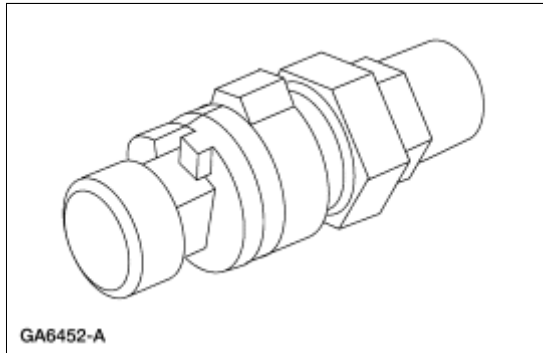
### Fuel Tank Temperature Sensor (CNG)

The fuel tank temperature (FTT) sensor is a thermistor mounted on the CNG fuel tank and is used to calculate fuel density. The Compuvalve sends the FTT a five volt reference. The FTT sensor is also used to keep the fuel gauge from fluctuating during temperature changes. A non-functioning sensor will give a constant reading of 15°C (59°F)(F-Series) or 0°C (32°C)(Contour).



### Fuel Tank Pressure Sensor (CNG)

The fuel tank pressure (FTP) sensor is integral to the gas regulator. It provides information on system pressure to the Compuvalve and is the main input for the alternative fuel gauge reading.



### Fuel Absolute Pressure Sensor

The fuel absolute pressure (FAP) sensor is integral to the Compuvalve. It is a pressure transducer that converts pressure to voltage through a piezo-resistive element. This signal is monitored to make sure that the pressure regulator is functioning properly and is used to adjust the injector combination according to supply pressure. The FAP sensor allows the vehicle to start in ALT fuel mode at a minimum of 95 psia (CNG) or minimum 25 psia (LPG). It also controls when the vehicle will auto switch, 45 psia (CNG) or 25 psia (LPG).

### Fuel Rail Temperature Sensor

The fuel rail temperature (FRT) sensor is integral to the Compuvalve. The FRT is used to calculate fuel density. It is supplied five volts from the Compuvalve and as the temperature of the sensing element increases, its resistance increases.

### Manifold Absolute Pressure Sensor

The manifold absolute pressure (MAP) sensor is integral to the Compuvalve. It is a pressure transducer that converts pressure to voltage through a piezo-resistive element. It is attached to the intake manifold via a vacuum line with a damper tube that is routed to an external hose barb on the Compuvalve. MAP is used to monitor engine operating state.

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## Malfunction Indicator Lamp (MIL)

Alternative fuel diagnostics are automatic, active, continuous monitor of the bi-fuel system when the vehicle is operating in liquefied petroleum gas (LPG) or compressed natural gas (CNG) mode. The system monitors the activity of system inputs and compares the values to calibrated reference criteria. If a signal does not satisfy the reference criteria, a fault code is generated and stored. If the fault is of an emissions-critical nature, the system will illuminate the malfunction indicator lamp (MIL). Additionally, the selector switch light will change from a steady on to an irregular flashing condition. If the fault condition stops, the MIL will return to normal status after three trips (CNG) or two trips (LPG) and the fault code is stored for access during diagnostic procedures. If the fault condition does not occur for forty trips, the fault code is erased. If a temperature-related fault occurs, the Compuvalve will operate using a default value to protect the engine from severe over or under fueling. The Compuvalve will continue to use the default value until the next key off/ key on cycle.

### Malfunction Indicator Lamp (MIL) (Contour)

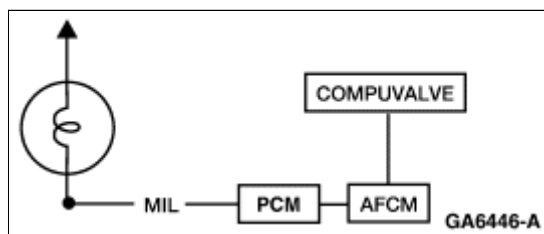


Figure 1.

### Malfunction Indicator Lamp (MIL) (All others)

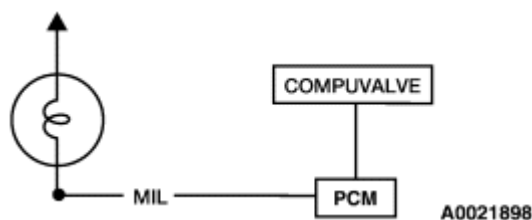


Figure 2.

