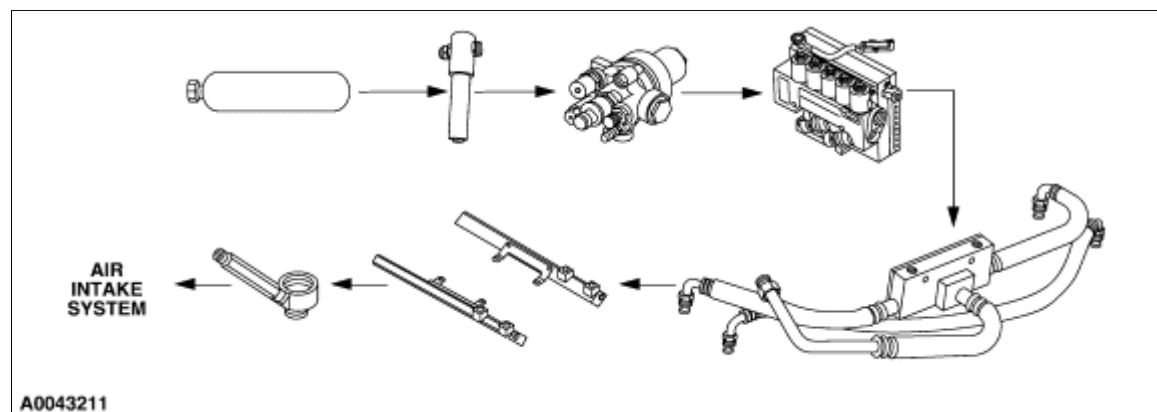


## Fuel System

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 factory set adjustable tuning tee, fuel rails, fuel injector sleeves, an ALT/GAS switch, an ALT/GAS switch light and an ALT fuse/relay module, and a solenoid tank valve (CNG).

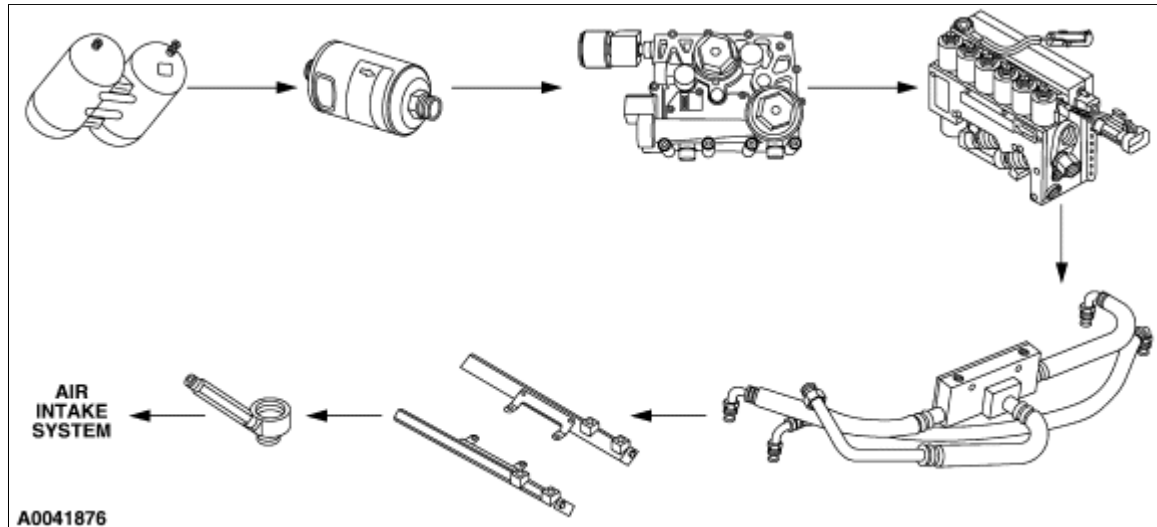
### Compressed Natural Gas (CNG) System

Fuel from the compressed natural gas (CNG) fuel tanks flows through the solenoid tank valve and coalescent fuel filter to the gas regulator. The gas regulator provides a consistent system operating fuel pressure of approximately 115 psia. 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 powertrain control module (PCM) 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 fuel rails and to the intake air system through the fuel injector sleeve assembly.



### Liquefied Petroleum Gas (LPG) System

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. 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 a factory set adjustable tuning tee, through the fuel rail assemblies and is introduced into the intake system through fuel injector sleeve assemblies.



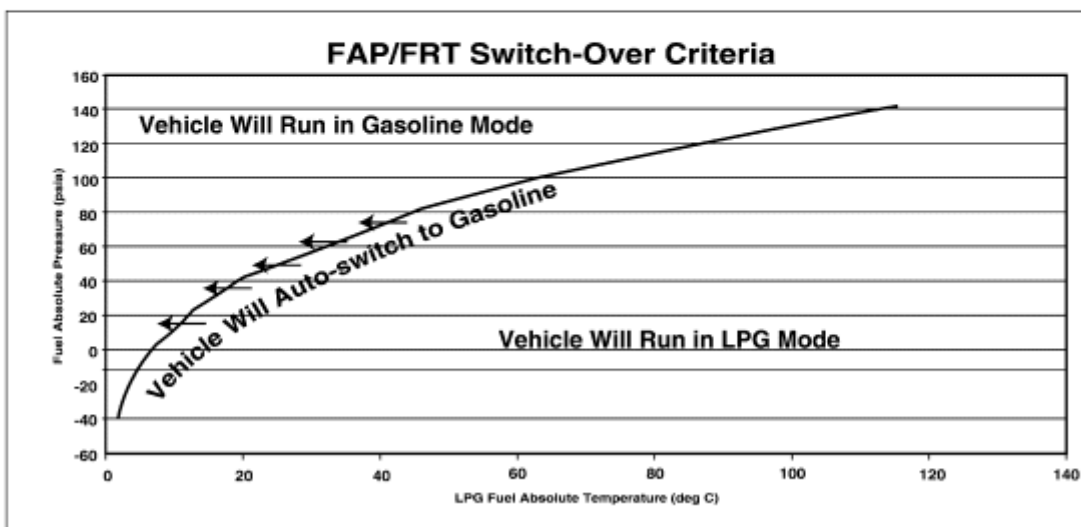
### Bi-Fuel Switch-Over Pressures and Temperatures

If engine operating temperature is excessively cold, LPG or CNG operation may be delayed until fuel temperature at the vaporizer reaches a sufficiently high level to permit consistent operation fuel pressure.

**Bi-Fuel Switch-Over Pressures & Temperatures Chart**

FAP\_OK = The minimum Fuel Absolute Pressure (CNG or LPG) the MV must see at key up to start on the alternative fuel.  
 FAP\_LOW = If the Fuel Absolute Pressure falls below this level while running on the alternative fuel the vehicle will auto-switch to gasoline.  
 FRT\_AUTOSWITCH = If the alternative fuel temperature is below this value the vehicle will auto-switch to gasoline.  
 FAP\_FRT\_SWITCHOVER\_CURVE = If the alternative fuel temp is below (to the left of) the Vap/Liquid line defined by the chart below the vehicle will auto-switch to gasoline **LPG ONLY**.  
 This may occur if a high fuel demand is placed on the engine before the coolant has warmed up.

Fuel	Model	Cal File	FAP_OK psia	FAP_OK InHga	FAP_LOW psia	FAP_LOW InHga	FRT_AUTOSWITCH deg F	FRT_AUTOSWITCH deg C	FRT_AUTOSWITCH deg K
CNG	F Series	6F5F1C01.R00	95	193	68.5	140	-81	-63	210
LPG	F Series L	6F5F1P01.R00	24.5	50	24.5	50	-13	-25	248
LPG	F Series H	6F5F2P01.R00	24.5	50	24.5	50	-13	-25	248



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### Alternative Fuel Tank

The CNG and LPG fuel tanks are refillable storage tanks requiring replacement only when damaged or upon failing an inspection. The CNG tanks are equipped with a non-repairable pressure relief device (PRD) and an expiration date. 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 CNG and LPG fuel tanks are connected to the fill valve by a high-pressure hose.

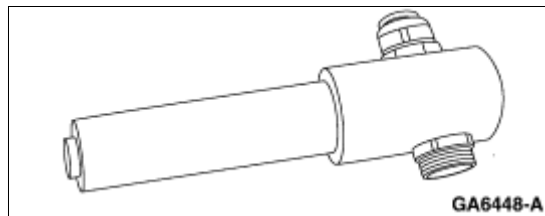
The F-150 is supplied with either single (CNG and LPG) or dual (LPG only) tank configurations, which are bolted inside the forward area of the bed floor.

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

The CNG fuel tank 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.

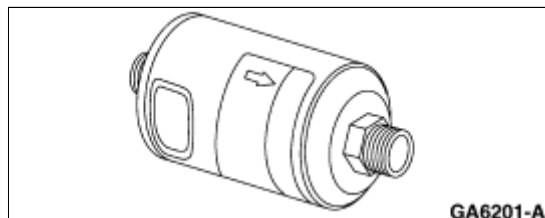
### Coalescent Fuel Filter (CNG)

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

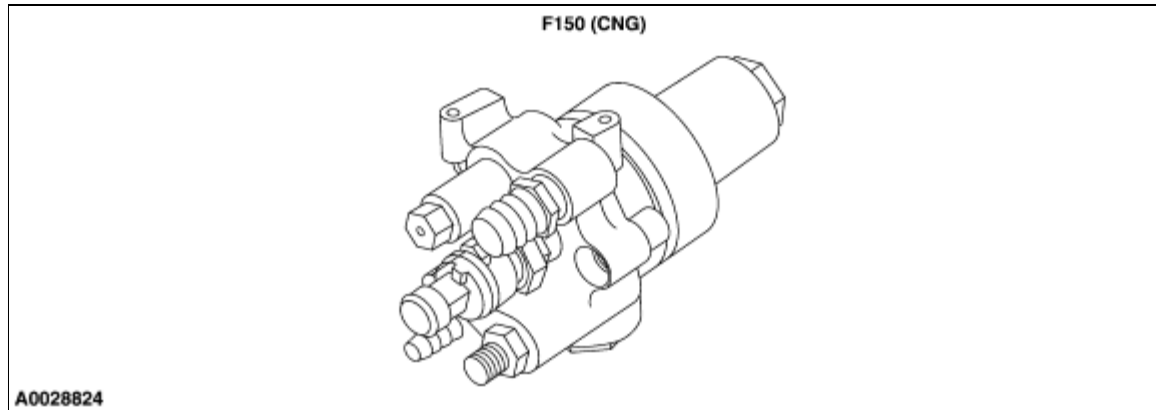


### Fuel Injector Valves

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 fuse/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.

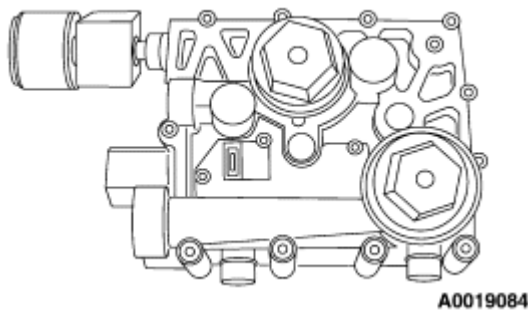
## Gas Regulator (CNG)

High pressure CNG enters the high pressure regulator. The gas regulator delivers fuel at 115 psia to the compuvalve.



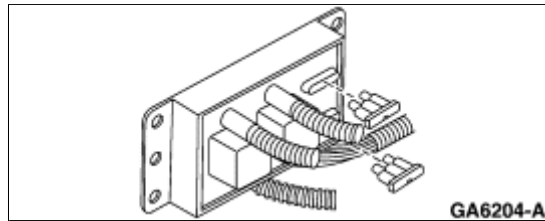
## Vaporizer (LPG)

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.



## ALT Fuse/Relay Module

The ALT fuse/relay module contains two replaceable fuses. Refer to the Wiring Diagrams Manual for fuse location. 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 fuse/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.



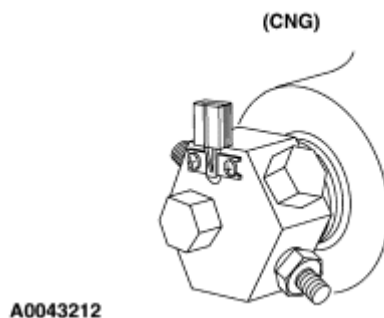
## Alternative Fuel Control Module (AFCM)

The alternative fuel control module (AFCM) is incorporated within the compuvalve and 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.

## Solenoid Tank Valves (CNG)

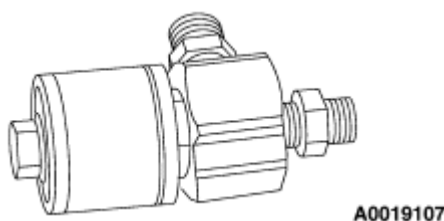
The tank valve solenoid receives VPWR from the inertia fuel shutoff (IFS) switch. If the IFS is tripped for any reason (i.e. accident), or if the key is on and there is no tach signal received, the tank valve will be closed.

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 PID drops to 75 psia (CNG) or 25 psia (LPG).



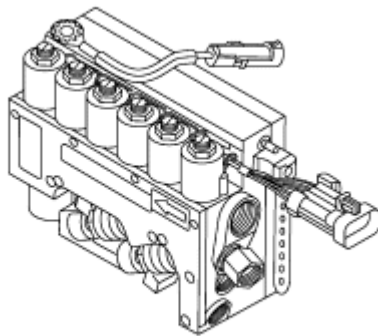
## Solenoid Lockoff Valve (LPG)

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

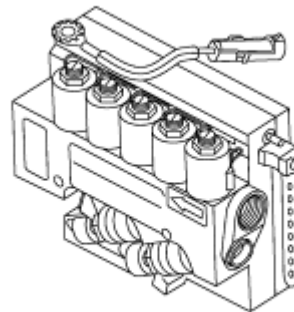


## Compuvalve

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 and through the injector sleeves. Internal to the compuvalve are the fuel absolute pressure (FAP) sensor, the fuel rail temperature (FRT) sensor, the manifold absolute pressure (MAP) sensor, and the alternative fuel control module (AFCM). The compuvalve communicates to the instrument cluster (on the SCP lines) 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.



LPG



CNG

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## 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 and sends a 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.

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

The ALT/GAS switch permits the driver to select which fuel the vehicle will operate on. The ALT/GAS switch is located on the instrument panel.

The ALT/GAS switch only operates when the vehicle is at a stop with the ignition in the OFF position. If the

switch is moved while the vehicle is running, the gaseous fuel system will NOT automatically change fuel mode and no damage to the vehicle will occur.

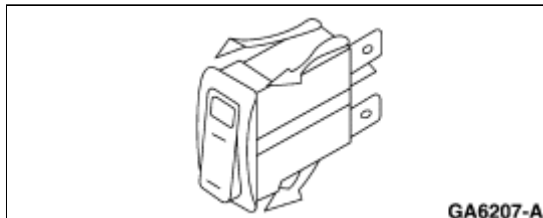
Prior to starting the vehicle (with the ignition in the OFF position), determine which fuel you intend to use and press the ALT/GAS switch.

When the selector switch is placed in the GAS position, the engine will operate in the unleaded gasoline mode.

When the switch is placed in the ALT position the engine will operate in the gaseous fuel mode (if temperature and pressure conditions are correct), running on CNG or LPG (depending upon application). A green indicator light will illuminate on the fuel selector switch to indicate that the vehicle is operating in the gaseous fuel mode (CNG or LPG, depending upon application).

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 ALT/GAS switch light has the following status modes:

- OFF
- ON STEADY
- ON THEN OFF (Quickly or Slowly)
- FLASHING (REGULAR OR IRREGULAR) (Quickly or Slowly)



## Fuel Gauge

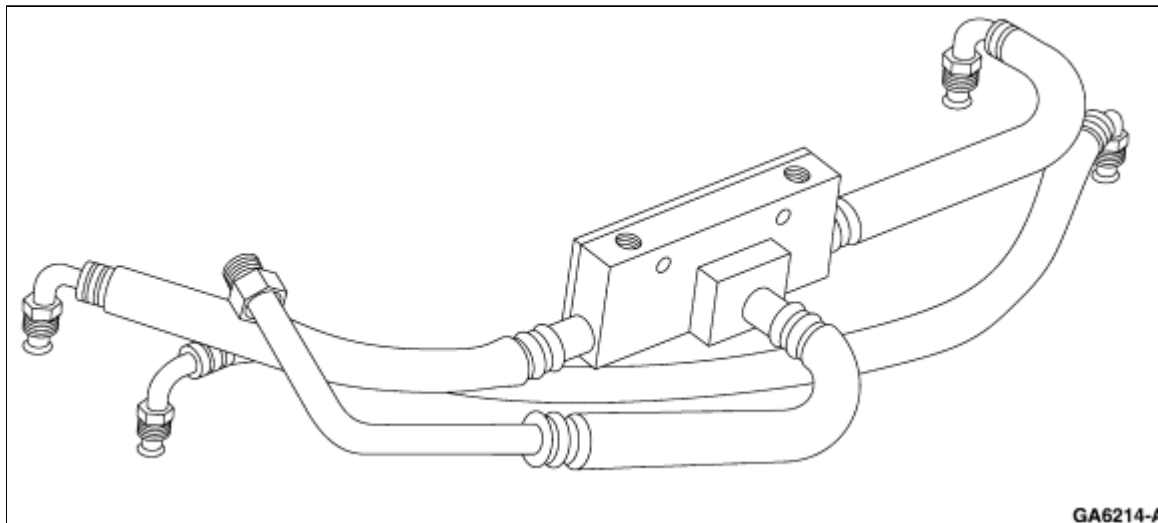
Fuel gauge operation in a CNG or LPG Bi-Fuel vehicle (depending upon application) behaves similarly to a standard gasoline fuel gauge. The fuel gauge provides a linear reading from full down to empty.

- Fuel gauge operation for an LPG Bi-Fuel vehicle is based on a float type sensor measuring the level of the liquid propane in the fuel tanks.
- Fuel gauge operation for a CNG Bi-Fuel vehicle is based on the pressure and temperature of the natural gas in the fuel tank(s). A full fuel gauge reading will occur at a pressure of approximately 24,800 kPa (3,600 psi) at a temperature of approximately 21 °C (70 °F). For more information on fuel gauge performance during the fast-fill method of CNG fueling, refer to the Owner Literature.

F-Series vehicles have their instrument cluster connected to the SCP bus (BUS+ and BUS-). Intercepts are not required in the fuel gauge and instrument cluster power signals because the Bi-Fuel system can send fuel level data over the SCP bus. Refer to the Wiring Diagrams Manual for information about Bi-Fuel system electrical taps and intercepts.

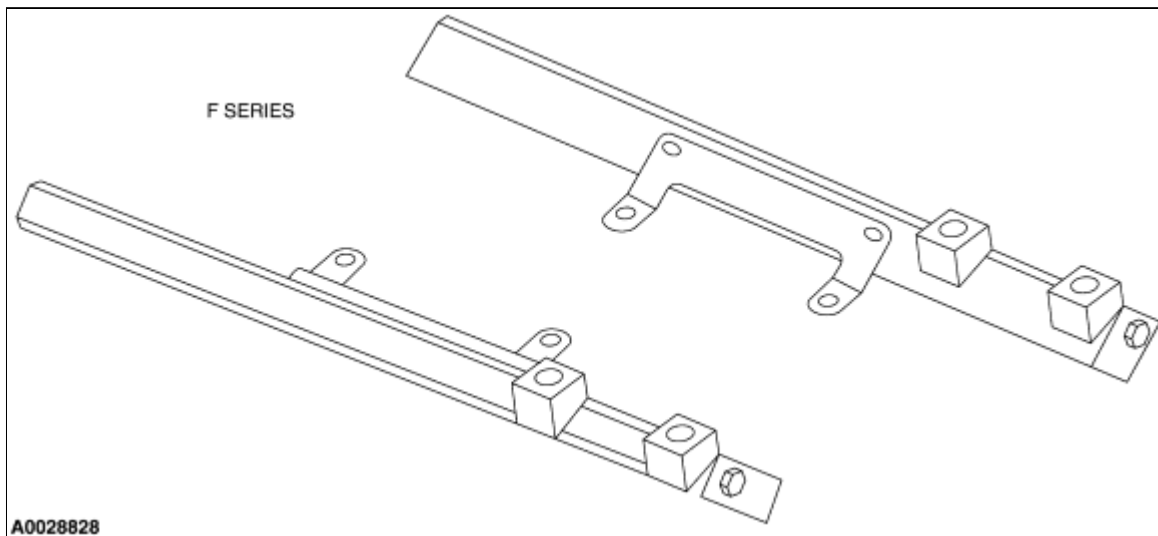
## Adjustable Tuning Tee

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. The tuning tee is preset at the factory. No adjustments are necessary unless the tuning tee is replaced.



## Fuel Rail

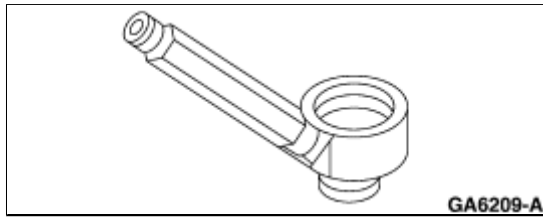
The fuel rails route alternative fuel from the compuvalve to the base vehicle intake runners.



## Injector Sleeves

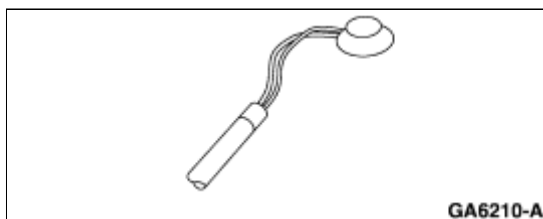
The injector sleeves are placed in the injector seats. The gasoline fuel injectors are placed in the injector sleeve seats. The sleeves bypass the gasoline fuel injectors, delivering alternative fuel into the intake system and provide a path of fuel flow from the gasoline injectors.





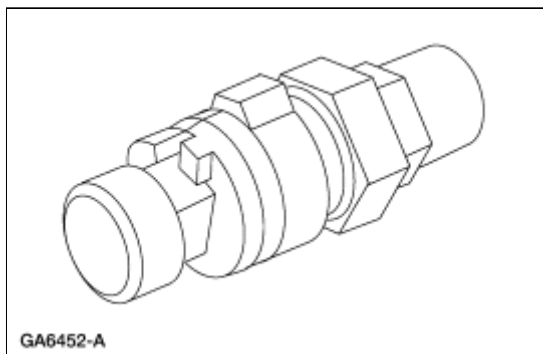
### Fuel Tank Temperature Sensor (CNG)

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).



### 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, 75 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, and 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.

