MI-04 4.3L LPG SYSTEM SERVICE MANUAL 91507B

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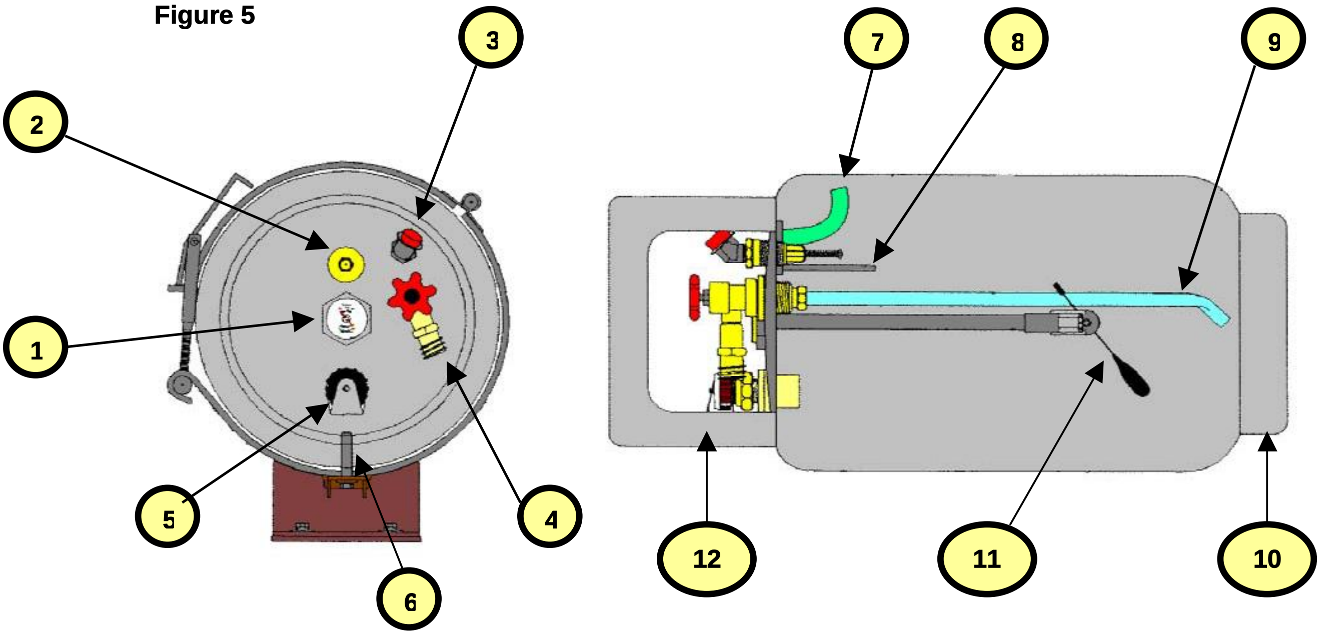
Figure 5



Fuel Gauge

In figure 5 a visual fuel gauge is used to show the fuel level in the tank. A mechanical float mechanism detects the liquid propane level. A magnet on the end of the float shaft moves a magnetic pointer in the fuel gauge. Some units have an electronic sending unit using a variable resistor, installed in place of a gauge for remote monitoring of the fuel level. The gauge may be changed with fuel in the tank. **DO NOT REMOVE THE FOUR LARGE FLANGE BOLTS THAT RETAIN THE FLOAT ASSEMBLY, WITH FUEL IN THE TANK!**

WARNING
It is not a legal practice to fill the tank through the liquid contents gauge.

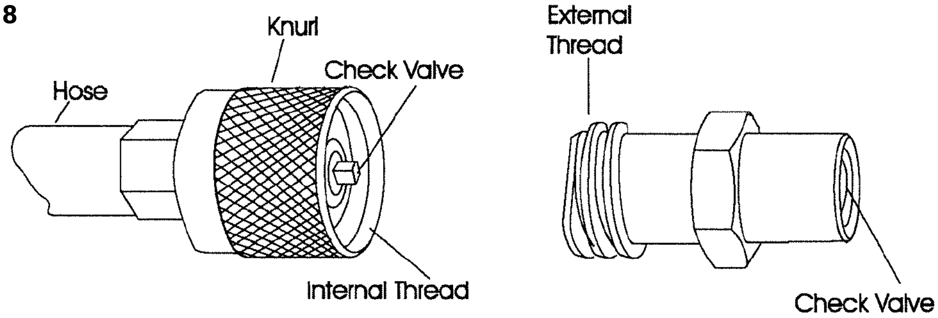
Quick Disconnect Coupling

The liquid withdrawal or service valve on a DOT tank has male threads and accepts the female portion of a quick disconnect coupling (**Figure 8**). The female portion is adapted to the liquid hose going to the fuel system. Both halves are equipped with 100% shutoffs, which open when coupled together to allow fuel flow. The coupler has two seals. One is an o-ring and the other is a flat washer. The o-ring prevents leakage from the shaft on the other coupling and the flat washer seals when the coupler is fully connected.

NOTE

The flat seal and/or the o-ring will sometimes pop off when disconnecting and slide up the shaft of the mating connector, causing the valve not to open when fully mated. The extra washer or o-ring must be removed from the shaft and the coupling reconnected.

Figure 8

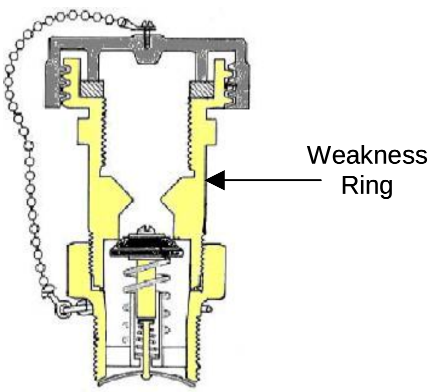


Filler Valve

The liquid filler valve (**Figure 9**) has a male thread to receive a fuel nozzle and typically has a plastic or brass screw on cap that is retained with a small chain or plastic band to keep debris out of the filler valve. The filler valve is a one-way flow device that uses two check valves to allow fuel to enter the tank but prevent it from exiting. Both check valves are backpressure type check valves, designed so that backpressure from the tank assists the check valves own spring pressure to close the valve. The first valve uses a neoprene on metal seal and the second valve uses a metal on metal seal.

A weakness ring is machined into the filler valve just above the check valves and will allow the filler valve to shear off in case of an accident. The valve will break or shear off above the check valves so that the tank will be sealed and no liquid propane can escape.

Figure 9



CHAPTER 2.0 MI-04 LPG SYSTEM OPERATIONAL OVERVIEW 4.3L

MI-04 General Description

Woodward s MI-04 control system is designed to provide a complete, fully integrated solution that will meet or exceed TIER-2 Large Spark Ignited Engines emission standards established by the California Air Research Board (CARB) and the Environmental Protection Agency (EPA) for 2004. The MI-04 is a closed loop system utilizing a catalytic muffler to reduce the emission level in the exhaust gas. In order to obtain maximum effect from the catalyst, an accurate control of the air fuel ratio is required. A small engine control module (SECM) uses a heated exhaust gas oxygen sensor (HEGO) in the exhaust system to monitor exhaust gas content.

MI-04 System with the N-CA100TR Mixer

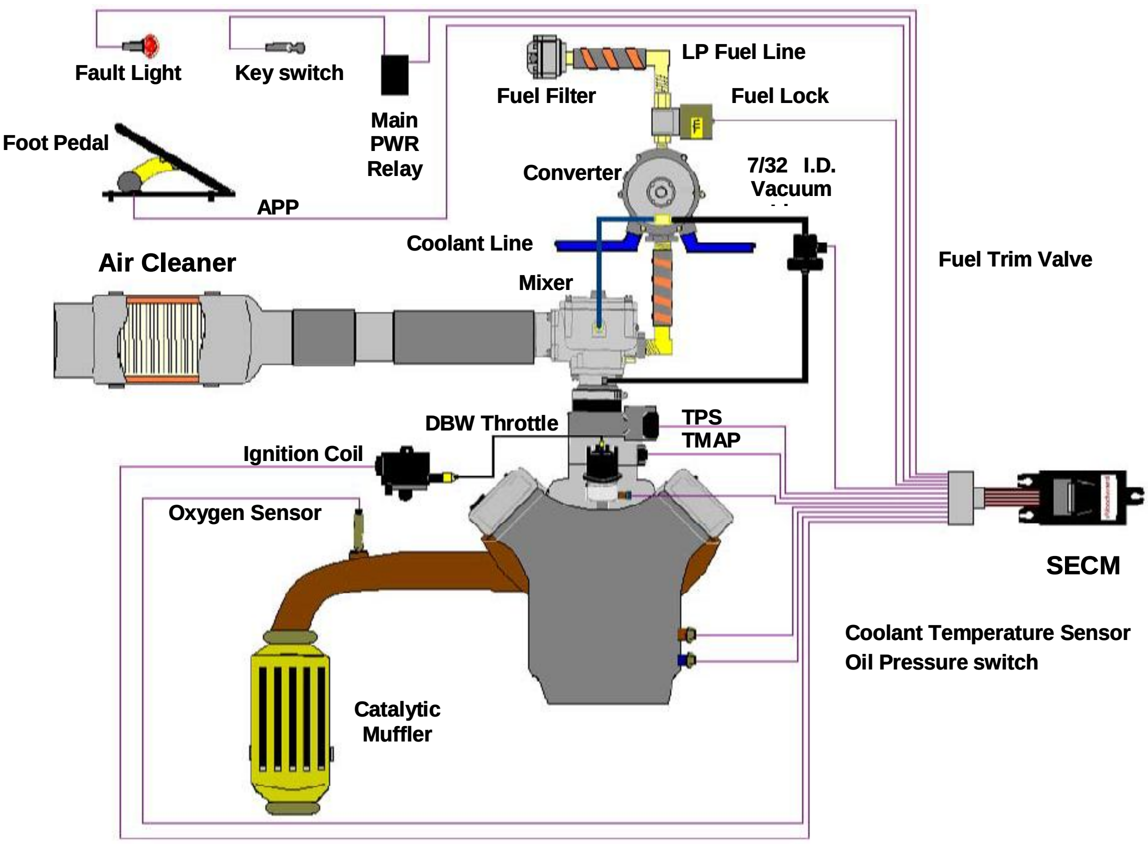
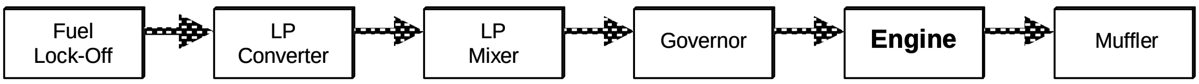


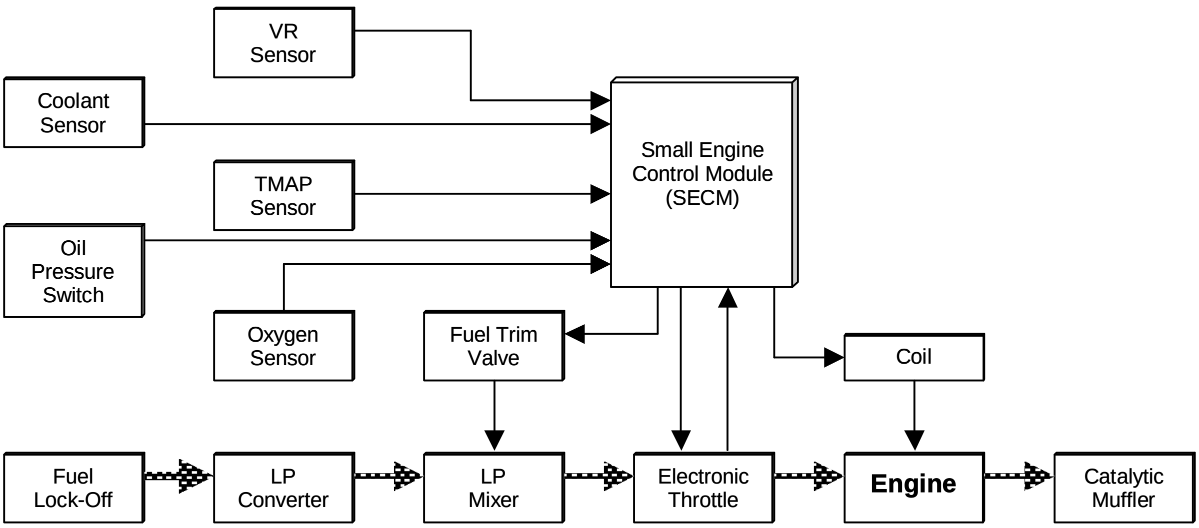
Figure 10

The SECM makes any necessary corrections to the air fuel ratio by controlling the inlet fuel pressure to the air/fuel mixer by modulating the fuel trim valve (FTV) connected to the regulator. Reducing the fuel pressure leans the air/fuel mixture and increasing the fuel pressure enriches the air/fuel mixture. To calculate any necessary corrections to the air fuel ratio, the SECM uses a number of different sensors to gain information about the engines performance. Engine speed is monitored by the SECM through a variable reluctance (VR) sensor. Intake manifold air temperature and absolute pressure is monitored with a (TMAP) sensor. The MI-04 is a drive by wire (DBW) system connecting the accelerator pedal to the electronic throttle through the electrical harness; mechanical cables are not used. A throttle position sensor (TPS) monitors throttle position in relation to the accelerator pedal position sensor (APP) feedback. Even engine coolant temperature and adequate oil pressure is monitored by the SECM. The SECM controller has full adaptive learning capabilities, allowing it to adapt control function as operating conditions change. Factors such as ambient temperature, fuel variations, ignition component wear, clogged air filter, and other operating variables are compensated.

Open Loop LP Fuel System



MI-04 Closed Loop LP Fuel System



MI-04 LP Fuel Filter

After exiting the fuel tank, liquid propane passes through a serviceable inline fuel filter to the electric fuel lock off. (**Figure 11**) shows a typical inline type LP fuel filter manufactured by Century. The primary function of the fuel filter is to remove particles and sediments that have found their way into the tank. The LP fuel filter will not remove heavy end solids and paraffins that build up in LPG fuel systems as a result of vaporization.

Figure 11

MI-04 Fuel Lock-Off (Electric)

The fuel lock-off is a safety shutoff valve, normally held closed by spring pressure, which is operated by an electric solenoid and prevents fuel flow to the regulator/converter when the engine is not in operation. This is the first of three safety locks in the MI-04 system. (**Figure 12**) shows the electric fuel lock assembly.

In the MI-04 design, power is supplied to the fuel lock-off with the SECM controlling the lock-off ground (earth) connection. The lock-off remains in a normally closed (NC) position until the key switch is activated, this supplies power to the lock-off and the SECM but will not open the lock-off until the SECM provides the lock-off ground connection. This design gives the SECM full control of the lock-off while providing additional safety by closing the fuel lock-off in the unlikely event of a power failure, wiring failure or module failure.

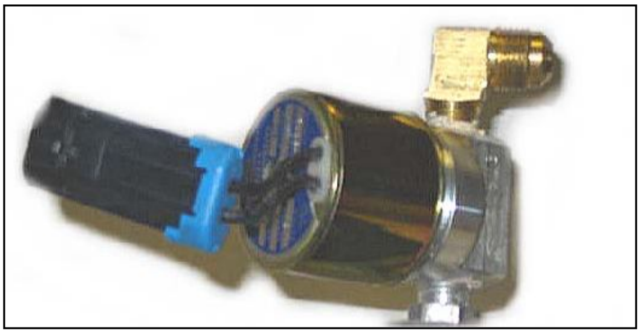


Figure 12

When the liquid service valve in the fuel container is opened liquid propane flows through the LP filter and through the service line to the fuel lock-off. Liquid propane enters the lock-off through the ¼ NPT liquid inlet port and stops with the lock-off in the normally closed position. When the engine is cranked over the main power relay applies power to the lock-off and the SECM provides the lock-off ground causing current to flow through the windings of the solenoid creating a magnetic field. The strength of this magnetic field is sufficient to lift the lock-off valve off of its seat against spring pressure. When the valve is open liquid propane, at tank pressure, flows through the lock-off outlet to the pressure regulator/converter. A stall safety shutoff feature is built into the SECM to close the lock-off in case of a stall condition. The SECM monitors three engine states. Crank, when the VR sensor detects any engine revolutions. Stall, when the key is in the ON position but the VR sensor detects no engine revolutions, and the Run state, when the engine reaches pre-idle RPM. When an operator turns on the key switch the lock-off is opened but if the operator fails to crank the engine, the SECM will close the lock-off after 5 seconds.

MI-04 N-2001 Regulator/Converter

After passing through the electric fuel lock-off, liquid propane enters the N-2001 regulator/converter (**Figure 13**). The N-2001 functions as a fuel vaporizer, converting liquid propane to vapor propane and as a two-stage negative pressure regulator, supplying the correct vapor propane fuel pressure to the mixer.

The regulator is normally closed requiring a vacuum signal (negative pressure) to allow fuel to flow. This is the second of three safety locks in the MI-04 system. If the engine stops, vacuum signal stops and fuel flow will automatically stop when both the secondary (2nd stage) valve and the primary (1st stage) valve closes. Unlike most other regulator/converters, the N-2001 primary valve closes with fuel pressure rather than against pressure, extending primary seat life and adding additional safety.

Figure 13

Liquid propane must be converted into a gaseous form in order to be used as a fuel for the engine. When the regulator receives the desired vacuum signal it allows propane to flow to the mixer. As the propane flows through the regulator the pressure is reduced in two stages from tank pressure to slightly less than atmospheric pressure. As the pressure of the propane is reduced the liquid propane vaporizes and refrigeration occurs inside the regulator due to the large temperature drop inside the regulator from the vaporization of liquid propane. To replace heat lost to vaporization, engine coolant is supplied by the engine driven water pump and pumped through the regulator. Heat provided by this coolant is transferred through to the fuel vaporization chamber.

(**Figure 14**) shows the heat chamber and the coolant passage in the N-2001.

N-2001
Heat Transfer Chamber

Coolant Passage

Figure 14

N-2001 Theory of Operation

N-2001
Cutaway View

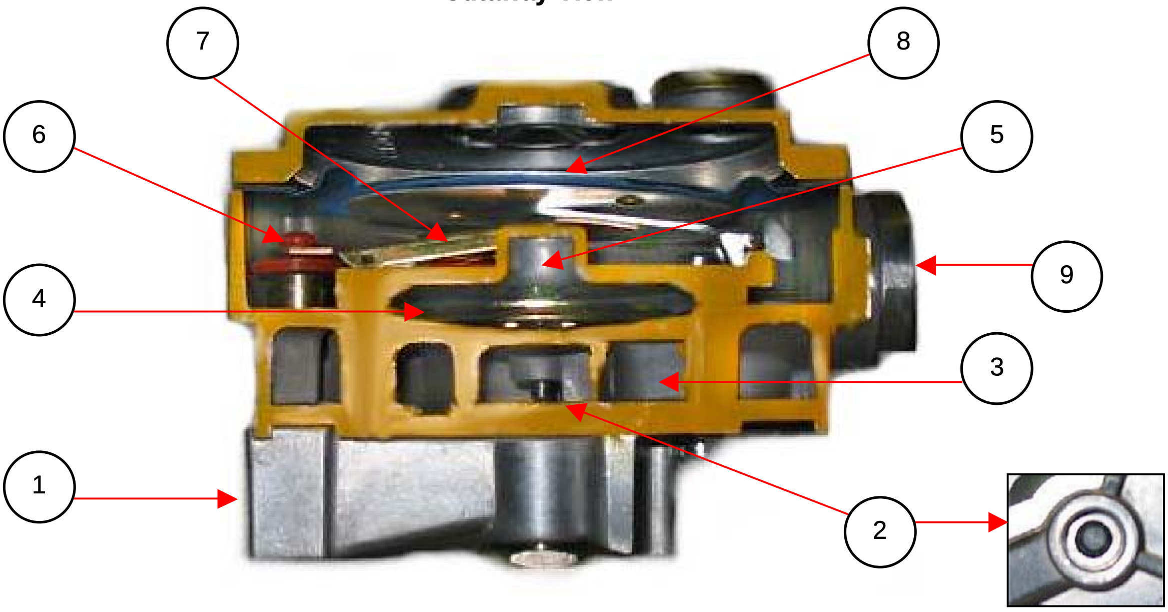


Figure 15

Liquid propane, at tank pressure, enters the N-2001 through the fuel inlet port (**1**). Propane liquid then flows through the primary valve (**2**). The primary valve located at the inlet of the expansion chamber (**3**), is controlled by the primary diaphragm (**4**), which reacts to vapor pressure inside the expansion chamber. Two springs are used to apply force on the primary diaphragm in the primary diaphragm chamber (**5**), keeping the primary valve open when no fuel pressure is present.
A small port connects the expansion chamber to the primary diaphragm chamber. At the outlet of the expansion chamber is the secondary valve (**6**). The secondary valve is held closed by the secondary spring on the secondary valve lever (**7**). The secondary diaphragm controls the secondary lever. When the pressure in the expansion chamber reaches 1.5 psi it causes a pressure/force imbalance across the primary diaphragm (**8**). This force is greater than the primary diaphragm spring pressure and will cause the diaphragm to close the primary valve.

Since the fuel pressure has been reduced from tank pressure to 1.5 psi the liquid propane vaporizes. As the propane vaporizes it takes on heat from the expansion chamber. This heat is replaced by engine coolant, which is pumped through the coolant passage of the regulator. At this point vapor propane will not flow past the expansion chamber of the regulator until the secondary valve is opened. To open the secondary valve a negative pressure signal must be received from the air/fuel mixer. When the engine is cranking or running a negative pressure signal (vacuum) travels through the vapor fuel outlet connection of the regulator (**9**), which is the regulator secondary chamber, and the vapor fuel inlet of the mixer. The negative pressure in the secondary chamber causes a pressure/force imbalance on the secondary diaphragm, which overcomes the secondary spring force, opening the secondary valve and allowing vapor propane to flow out of the expansion chamber, through the secondary chamber to the mixer.

Because vapor propane has now left the expansion chamber, the pressure in the chamber will drop, causing the primary diaphragm spring force to re-open the primary valve allowing liquid propane to enter the regulator, and the entire process starts again. This creates a balanced condition between the primary and secondary chambers allowing for a constant flow of fuel to the mixer as long as the demand from the engine is present. The fuel flow is maintained at a constant output pressure, due to the calibrated secondary spring. The amount of fuel flowing will vary depending on how far the secondary valve opens in response to the negative pressure signal generated by the air/fuel mixer. The strength of that negative pressure signal developed by the mixer is directly related to the amount of air flowing through the mixer into the engine. With this process, the larger the quantity of air flowing into the engine, the larger the amount of fuel flowing to the mixer.

MI-04 (N-CA100TR Mixer)

Vapor propane fuel is supplied to the N-CA100TR mixer by the N-2001 pressure regulator/converter. The N-CA100TR mixer uses a diaphragm type air valve assembly to operate a gas-metering valve inside the mixer. The gas-metering valve is normally closed, requiring a negative pressure (vacuum) signal from a cranking or running engine to open. This is the third of the three safety locks in the MI-04 system. If the engine stops or is turned off, the air valve assembly closes the gas-metering valve, stopping fuel flow past the mixer. The gas-metering valve controls the amount of fuel to be mixed with the incoming air at the proper ratio. The air/fuel mixture then travels past the throttle, through the intake manifold and into the engine cylinders where it is compressed, ignited and burned.

Figure 15

(**Figure 16**) shows the N-CA100TR mixer installed with the electronic throttle.

Figure 16