SERVICE REPAIR

Hyster G006 (H6.00-H7.00XL Europe) Forklift

MANUAL

HYSTER

ELECTRONIC CONTROLLED LPG/GASOLINE FUEL SYSTEM

GM 3.0L AND 4.3L EPA COMPLIANT ENGINES

H2.00-3.20XM (H40-65XM) [H177];
S2.00-3.20XM (S40-65XM) [D187];
H3.50-5.50XM (H70-120XM) [L005];
H6.00-7.00XL (H135-155XL, H135-155XL$_2$) [G006];
S6.00-7.00XL (S135-155XL, S155XLS, S135-155XL$_2$) [C024];
S3.50-5.50XM (S70-120XM) [F004]

HYSTER

PART NO. 1559540

900 SRM 1088

SAFETY PRECAUTIONS
MAINTENANCE AND REPAIR

- When lifting parts or assemblies, make sure all slings, chains, or cables are correctly fastened, and that the load being lifted is balanced. Make sure the crane, cables, and chains have the capacity to support the weight of the load.
- Do not lift heavy parts by hand, use a lifting mechanism.
- Wear safety glasses.
- DISCONNECT THE BATTERY CONNECTOR before doing any maintenance or repair on electric lift trucks. Disconnect the battery ground cable on internal combustion lift trucks.
- Always use correct blocks to prevent the unit from rolling or falling. See HOW TO PUT THE LIFT TRUCK ON BLOCKS in the **Operating Manual** or the **Periodic Maintenance** section.
- Keep the unit clean and the working area clean and orderly.
- Use the correct tools for the job.
- Keep the tools clean and in good condition.
- Always use **HYSTER APPROVED** parts when making repairs. Replacement parts must meet or exceed the specifications of the original equipment manufacturer.
- Make sure all nuts, bolts, snap rings, and other fastening devices are removed before using force to remove parts.
- Always fasten a DO NOT OPERATE tag to the controls of the unit when making repairs, or if the unit needs repairs.
- Be sure to follow the **WARNING** and **CAUTION** notes in the instructions.
- Gasoline, Liquid Petroleum Gas (LPG), Compressed Natural Gas (CNG), and Diesel fuel are flammable. Be sure to follow the necessary safety precautions when handling these fuels and when working on these fuel systems.
- Batteries generate flammable gas when they are being charged. Keep fire and sparks away from the area. Make sure the area is well ventilated.

NOTE: The following symbols and words indicate safety information in this manual:

WARNING

Indicates a condition that can cause immediate death or injury!

CAUTION

Indicates a condition that can cause property damage!

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General

This section has the description, operation, and repair procedures for the parts of the LPG and gasoline fuel systems used on the GM 3.0L and 4.3L engines.

Special service tools shown in this service manual that have tool product numbers beginning with "J" or "BT" are available for world wide distribution from Kent-Moore Tools.

FUEL SYSTEM WARNINGS AND CAUTIONS

It is important to note that this manual contains various Warnings, Cautions, and Notes that must be carefully observed in order to reduce the risk of personal injury during service or repair. Improper service or repair may damage the engine or render it unsafe or fail to make the engine emissions compliant. It is also important to warn of all hazardous consequences that might result from careless treatment of the engine. Failure to observe these items could influence terms of the warranty.

WARNING

Failure to heed could result in death, injury, or property damage.

WARNING

Do not smoke, carry lighted tobacco, or use a lighted flame of any type when working on or near any fuel related component. Highly flammable air/fuel mixtures may be present and can be ignited causing personal injury.

WARNING

Do not allow propane to contact the skin. Propane is stored in the fuel tank as a liquid. When propane contacts the atmosphere, it immediately expands into a gas, resulting in refrigeration that can cause severe burns.

WARNING

Do not allow propane to accumulate in areas below ground level such as in a service pit or underground ventilation systems. Propane is heavier than air and can displace oxygen, creating a dangerous condition.

CAUTION

Less severe than a WARNING, but has the potential to cause injury or damage to equipment. Also used to notify of situations that could lead to eventual failure, injury or damage.

CAUTION

Late model engines use a combination of standard and metric fasteners. The components affected are the starter motor, engine mounts, and flywheel housing mounting. Other components may also have a combination of fasteners. Always verify that the proper fasteners are used whenever removing or replacing any components.

To reduce the chance of personal injury and/or property damage, the following instructions must be carefully observed.

- Proper service and repair are important to the safety of the service technician and the safe reliable operation of all engines. The service procedures recommended and described in this service manual are effective methods of performing service and repair. Some of these procedures require the use of tools specially designed for the purpose.
- If part replacement is necessary, the replacement part must be of the same part number or equivalent part. Do not use a replacement part of lesser quality. In the case of replacement parts for the emission control system use only genuine HYSTER replacement parts.
- Before using a replacement part, service procedure, or a tool which is not recommended by the engine manufacturer, it must first be determined that neither personal safety nor the safe operation of the engine will be jeopardized by the replacement part, service procedure, or the tool selected.

Glossary

AVV - Air Valve Vacuum. The vacuum signal taken from below the air valve assembly and above the throttle butterfly.

Active Governor Mode - Speed is governed by one of two modes. Isochronous, which maintains an exact speed, or Droop, which allows speed to drop a predetermined amount based on current engine load.

Adaptive - Ability to compensate and adjust operating parameters.

AL - Adaptive Learn.

AL Mult - Adaptive Learn Multiplier. The adaptive learn multiplier is a correction to the fuel delivery which is expressed as a percentage and stored in the ECM's RAM.

Air/Fuel Ratio - The amount of air and fuel in the air fuel mixture, which enters the engine, shown in a ratio.

Analog - 0 to 5 volt or 0 to 12 volt signals.

Analog Voltmeter - A meter that uses a needle to point to a value on a scale of numbers usually of the low impedance type; used to measure voltage and resistance.

Aromatics - Pertaining to or containing the six-carbon ring characteristic of the benzene series. Found in many crude oils.

Backfire - Combustion of the air/fuel mixture in the intake or exhaust manifolds. A backfire can occur if the intake or exhaust valves are open when there is a mis-timed ignition spark.

BATT - Battery voltage.

Benzene - An aromatic (C_6H_6). Sometimes blended with gasoline to improve antiknock value. Benzene is toxic and suspected of causing cancer.

Bi-Fueled - A vehicle equipped to run on two fuels at the same time such as a fumigated diesel.

Blow-By - Gases formed by the combustion of fuel and air, which ordinarily should exert pressure only against the piston crown and first compression ring. When rings do not seal, these gases (blow-by) escape down the side of the piston into the crankcase.

BP - Barometric Pressure. The pressure of the outside air.

BTU - British Thermal Unit. A measurement of the amount of energy required to raise the temperature of 0.45 kg (1 lb) of water 0.555°C (1°F).

Butane - An odorless, colorless gas, C_4H_{10} found in natural gas and petroleum. One of the five LP gases.

CAFE - Corporate Average Fuel Economy.

Calibration - Identified as CAL on the diagnostic tools.

CARB - California Air Resources Board.

CO - Carbon Monoxide. A chemical compound of a highly toxic gas that is both, odorless and colorless.

Carburetor - An apparatus for supplying an internal combustion engine a mixture of vaporized fuel and air.

Cathode Ray Tube - A vaccum tube in which cathode rays, usually in the form of a slender beam, are projected on a fluorescent screen and produce a luminous spot.

CHT - Cylinder head temperature.

Circuit - A path of conductors through which electricity flows before it returns to its source.

CL - Closed Loop.

Closed Loop Operation - Applies to systems utilizing an oxygen sensor. In this mode of operation, the system uses oxygen sensor information to determine air/fuel ratio. Adjustments are made accordingly and checked by comparing the new oxygen sensor to previous signals. No stored information is used.

CNG - Compressed Natural Gas.

CKP - Crankshaft Position Sensor.

CMP - Camshaft Position Sensor.

Conductor - A material, normally metallic, that permits easy passage of electricity.

Contaminants - Impurities or foreign material present in fuel.

Control Module - One of several names for a solid state microcomputer which monitors engine conditions and controls certain engine functions; i.e. air/fuel ratio, injection and ignition time, etc.

Converter - A LPG fuel system component containing varying stages of fuel pressure regulation combined with a vaporizer.

Cryogen - A refrigerant used to obtain very low temperatures.

Current - The directed flow of electrons through a conductor. Measured in amps.

Dedicated Fuel System - A motor fuel system designed to operate on only one fuel type.

Diaphragm - A thin, flexible membrane that separates two chambers. When the pressure in one chamber is lower than in the other chamber, the diaphragm will move toward the side with the low pressure.

Diaphragm Port - The external port located at the fuel inlet assembly and connected to the vacuum chamber above the air valve diaphragm.

DVOM - Digital Volt/Ohmmeter. A meter that uses a numerical display in place of a gauge and is usually of the high impedance type.

DTC - Diagnostic Trouble Code.

ECT - Engine Coolant Temperature.

ECM - Electronic Control module.

EFI - Electronic Fuel Injection. A fuel injection system which uses a microcomputer to determine and control the amount of fuel, required by and injected into, a particular engine.

EGR - Exhaust gas recirculation.

EPA - Environmental Protection Agency: A regulating agency of the Federal government which, among other duties, establishes and enforces automotive emissions standards.

Ethanol - Grain alcohol (C_2H_5OH), generally produced by fermenting starch or sugar crops.

EEC - Evaporative Emissions Controls. An automotive emission control system designed to reduce hydrocarbon emissions by trapping evaporated fuel vapors from the fuel system.

Excess Flow Valve - A check valve that is caused to close by the fuel when the flow exceeds a predetermined rate.

FTV - Fuel Trim Valve.

FFV - Flexible Fuel Vehicle.

Firing Line - The portion of an oscilloscope pattern that represents the total amount of voltage being expended through the secondary circuit.

FPP - Foot Pedal Position Sensor.

Fuel Injector - A spring-loaded, electromagnetic valve which delivers fuel into the intake manifold, in response to an electrical pulse or signal from the control module.

Fuel Lock - A solenoid-controlled valve located in the fuel line to stop the flow when the engine stops or the ignition switch is **OFF**.

Gasohol - 10 percent ethanol, 90 percent gasoline. Often referred to as E-10.

Gasoline - A motor vehicle fuel that is a complex blend of hydrocarbons and additives. Typical octane level is 89.

Greenhouse Effect - A scientific theory that suggests that excessive levels of carbon dioxide from the burning of fossil fuels is causing the atmosphere to trap heat and cause global warming.

HD 10 - A fuel of not less than 80 percent liquid volume propane and not more than 10 percent liquid volume propylene.

HD 5 - A fuel of not less than 90 percent liquid volume propane and not more than 5 percent liquid volume propylene.

HEGO - Heated Oxygen Sensor.

HDV - Heavy Duty Vehicle.

Hg - Chemical symbol for mercury. Used in reference to vacuum (in. of Hg).

Hydrocarbon - A chemical compound made up of hydrogen and carbon (HC). A major pollution emission of the internal combustion engine. Gasoline and almost all other fuels are hydrocarbons.

Hydrostatic Relief Valve - A pressure relief device installed in the liquid propane hose on a propane fuel system.

IAT - Intake Air Temperature.

Ideal Mixture - The air/fuel ratio at which the best compromise of engine performance to exhaust emissions is obtained. Typically 14.7:1 for gasoline and 15.6:1 for LPG.

Ignition Reserve - The difference between available voltage and the required voltage.

IMPCO - Imperial Machine Products Company. IMPCO Technologies, Inc. A manufacturer of both LPG and Gasoline fuel systems.

Impedance - A form of opposition of AC current flow (resistance) measured in ohms.

Insulation - A non-conductive material used to cover wires in electrical circuits to prevent the leakage of electricity and to protect the wire from corrosion.

Intercept - An electrical term for a type of splice where the original circuit is interrupted and redirected through another circuit.

IVS - Idle Validation Switch.

ITK - IMPCO Test Kit.

Knock - Sound produced when an engine's air/fuel mixture is ignited by something other than the spark plug, such as a hot spot in the combustion chamber. Can be caused by a fuel with an octane rating that is too low or maladjusted ignition timing. Also called detonation or ping.

Lambda Sensor - A feedback device, usually located in the exhaust manifold, which detects the amount of oxygen present in exhaust gases in relation to the surrounding atmosphere.

Lean Mixture - An air to fuel ratio above the stoichiometric ratio; too much air.

LEV - Low Emission Vehicle.

Limp-in or Limp-home - This term is used to describe the drivability characteristics of a failed computer system.

LPG - Liquefied Petroleum Gas. A fuel commonly known as propane consisting mostly of propane (C_3H_8), derived from the liquid components of natural gas stripped out before the gas enters the pipeline, and the lightest hydrocarbons produced during petroleum refining. Octane level is 107.

LPL - Low pressure lock-off.

MAP - Manifold Absolute Pressure. The pressure of the air in the intake manifold.

MAT - Manifold Air Temperature. The temperature of the air in the intake manifold.

M85 - A blend of gasoline and methanol consisting of 85 percent methanol and 15 percent gasoline.

Measurements of Pressure - 1 PSI=2.06 Hg (mercury)=27.72 in. H_2O (water column). At sea level atmospheric pressure is 29.92 in. Hg.

Methanol: Known as wood alcohol (CH_3OH), a light, volatile, flammable alcohol commonly made from natural gas.

MIL - Malfunction Indicator Lamp. A dash mounted light that illuminates when the ECM senses a system fault.

Misfire - Failure of the air/fuel mixture to ignite during the power stroke.

Mixer - Fuel introduction device that does not include a throttle plate.

MPFI - Multi-Point Fuel injection. A fuel injection system that uses one injector per cylinder mounted on the engine to spray fuel near the intake valve area of combustion chamber.

MTBE - Methyl Tertiary Butyl Ether. Oxygenate added to gasoline to reduce harmful emissions and to improve the octane rating.

Natural Gas - A gas formed naturally from buried organic material, composed of a mixture of hydrocarbons, with methane (CH_4) being the dominant component.

NOx - See Oxides of Nitrogen.

Octane Rating - The measurement of the antiknock value of a motor fuel.

Open-Loop - An operational mode during which control module memory information is used to determine air/fuel ratio, injection timing, etc., as opposed to actual oxygen sensor input.

Orifice - A port or passage with a calibrated opening designed to control or limit the amount of flow through it.

Oscilloscope - An instrument that converts voltage and frequency readings into traces on a cathode-ray tube.

Oxides of Nitrogen - Chemical compounds of nitrogen bonded to various amounts of oxygen (NOx). A chief smog-forming agent.

Oxygen Sensor - An automotive sensor that produces a signal in accordance with the oxygen content of the exhaust gas. See Lambda Sensor.

Oxygenate - MTBE, ethanol, and methanol. Oxygenates are added to gasoline to increase the oxygen content and therefore reduce exhaust emissions.

O-zone - A radical oxygen module (O_3) that is found in the upper atmosphere and filters out ultraviolet radiation from the sun. Ground level o-zone is formed by NOx during the formation of photochemical smog.

Particulates - Microscopic pieces of solid or liquid substances such as lead and carbon that are discharged into the atmosphere by internal combustion engines.

PCV - Positive Crankcase Ventilation. An automotive emission control system designed to reduce hydrocarbon emissions by routing crankcase fumes into the intake manifold rather than to the atmosphere.

PFI - Port Fuel Injection. An electromagnetically actuated solenoid fuel injector that injects fuel to each intake valve.

Pressure Differential - The differential between atmospheric pressure and intake manifold (referred to as vacuum) pressure.

Pressure Regulator - A device to control the pressure of fuel delivered to the fuel injector(s).

Primary Circuit - The low-voltage or input side of the ignition coil.

Propane - An odorless, colorless gas, C_3H_8, found in natural gas and petroleum.

PSIA - Pounds per square inch absolute. 14.7 psia = 0 psig.

PTV - Pressure Trim Valve.

RAM - Random Access Memory. The portion of computer memory within the ECM, which changes as the engine is running and is stored while the engine is off.

Reactivity - Refers to the tendency of an HC in the presence of NOx and sunlight to cause a smog-forming reaction. The lighter the HC, the lower reactivity tends to be.

Regulator - An assembly used to reduce and control the pressure of a liquid or vapor.

Resistance - The opposition to the flow of current in an electrical circuit. Measured in ohms.

Rest Pressure - Fuel pressure maintained within the system after engine shutdown.

Rich Mixture - An air to fuel ratio below the stoichiometric ratio; too much fuel.

SAE - Society of Automotive Engineers.

Secondary Circuit - The high-voltage output side of the ignition coil.

SEFI or SFI - Sequential Electronic Fuel Injection or Sequential Fuel Injection.

Sensors - Devices that provide the control module with engine information as needed to properly control engine function.

Spark Line - The portion of an oscilloscope pattern that represents the time during which the air/fuel mixture is being burned in the combustion chamber.

Splice - An electrical term for the joining of two or more conductors at a single point.

Stoichiometric Ratio - An ideal fuel/air ratio for combustion in which all of the fuel and most of the oxygen will be burned.

Sulfur Oxides - Chemical compounds where sulfur is bonded to varying numbers of oxygen, produced by the combustion of gasoline or any other fuel that contains sulfur. As sulfur oxides decompose in the atmosphere, they combine with water to form sulfuric acid.

System Pressure - The fuel pressure maintained in the system during normal engine operation.

Tap - An electrical term for a type of splice where the original circuit is not interrupted.

TBI - Throttle Body Injection. Any of several injection systems that have the fuel injector(s) mounted in a centrally located throttle body.

Throttle Body - Controls engine RPM by adjusting the engine manifold vacuum to the mixer. Consists of housing shaft, throttle liner, and butterfly valve.

TMAP - Combined Air Inlet Temperature and Manifold Pressure Sensor.

Toluene - A liquid aromatic hydrocarbon C_7H_8.

TPS - Throttle Position Sensor.

TWC - Three-way catalyst used in a converter to reduce exhaust gas emissions of hydro-carbons, carbon monoxide, and nitrogen oxide in conjunction with closed loop fuel control.

Vaporization - A process in which liquid changes states into gas.

VAVV - Venturi Air Valve Vacuum. An amplified air valve vacuum signal coming from the venturi area of the mixer, directly exposed to airflow before the addition of vaporized LPG.

VOM - Volt/Ohmmeter. A combination meter used to measure voltage and resistance in an electrical circuit. Available in both analog and digital types. May be referred to as AVOM and DVOM.

Voltage - The electrical pressure that causes current to flow in a circuit. Measured in volts.

Voltage Drop - A lowering of the voltage in a circuit when resistance or electrical load is added.

Xylene - $C_6H_4(CH_3)_2$. Any of three toxic flammable oily isomeric aromatic hydrocarbons that are dimethyl homologues of benzene and are usually obtained from petroleum or natural gas distillates.

Description and Operation of LPG Fuel System

PROPANE FUEL SYSTEM

The primary components of the propane fuel system are the fuel storage tank, low pressure regulator (LPR), fuel mixer module with throttle control device, low pressure lock-off solenoid, electronic control module (ECM), fuel trim valve (FTV), pressure trim valve (PTV), and three-way catalytic (TWC) muffler. See Figure 1. The system operates at pressures which range from 355.6 mm (14 in.) of water column up to 21.5 bar (312 psi).

LPG FUEL TANK

Propane is stored in the fuel tank as a liquid. The approximate pressure of the fuel in the tank is 16.5 bar (240 psi) when the tank is full at an ambient temperature of 27°C (81°F). The boiling point (temperature at which the liquid fuel becomes vapor) is approximately −40°C (−40°F). When the fuel changes from liquid to vapor, the fuel expands and creates pressure inside the tank. When the tank service valve is opened, the pressure inside the tank forces the liquid fuel out through the pickup tube located near the bottom of the fuel cylinder. Because the propane is stored under pressure, the tank is equipped with safety valves which are normally set at 25.8 bar (375 psi) to prevent tank rupture due to over pressurization of the cylinder. The service valve, mounted in the end of the cylinder, controls the flow of fuel from the tank. By turning the handle to its open position, fuel flows out of the tank and into the service line. The service valve is also equipped with a safety feature called an excess flow check valve. This feature reduces the flow from the service valve in the event of a rupture of the fuel line or any down stream component. See Figure 2 for fuel tank components.

SERVICE LINE

CAUTION

The bulkhead assembly should never be removed and a service line run through the sheet metal.

Propane flows from the fuel tank to the electric lock via the service line. The service line is connected to the tank utilizing a quick coupler. The other end of the service line is connected to a bulkhead connector mounted on the equipment sheet metal. This bulkhead connector allows for a safe means of passing through the equipment's engine compartment sheet metal and into the engine compartment. If a bulkhead connector is used, a pressure relief device is mounted in the service line or the connector itself to prevent over pressurization of the service line. The service line is made of high pressure hose with special material or possibly tubing which is friendly to the LPG fuel and should always be replaced with a HYSTER approved part.

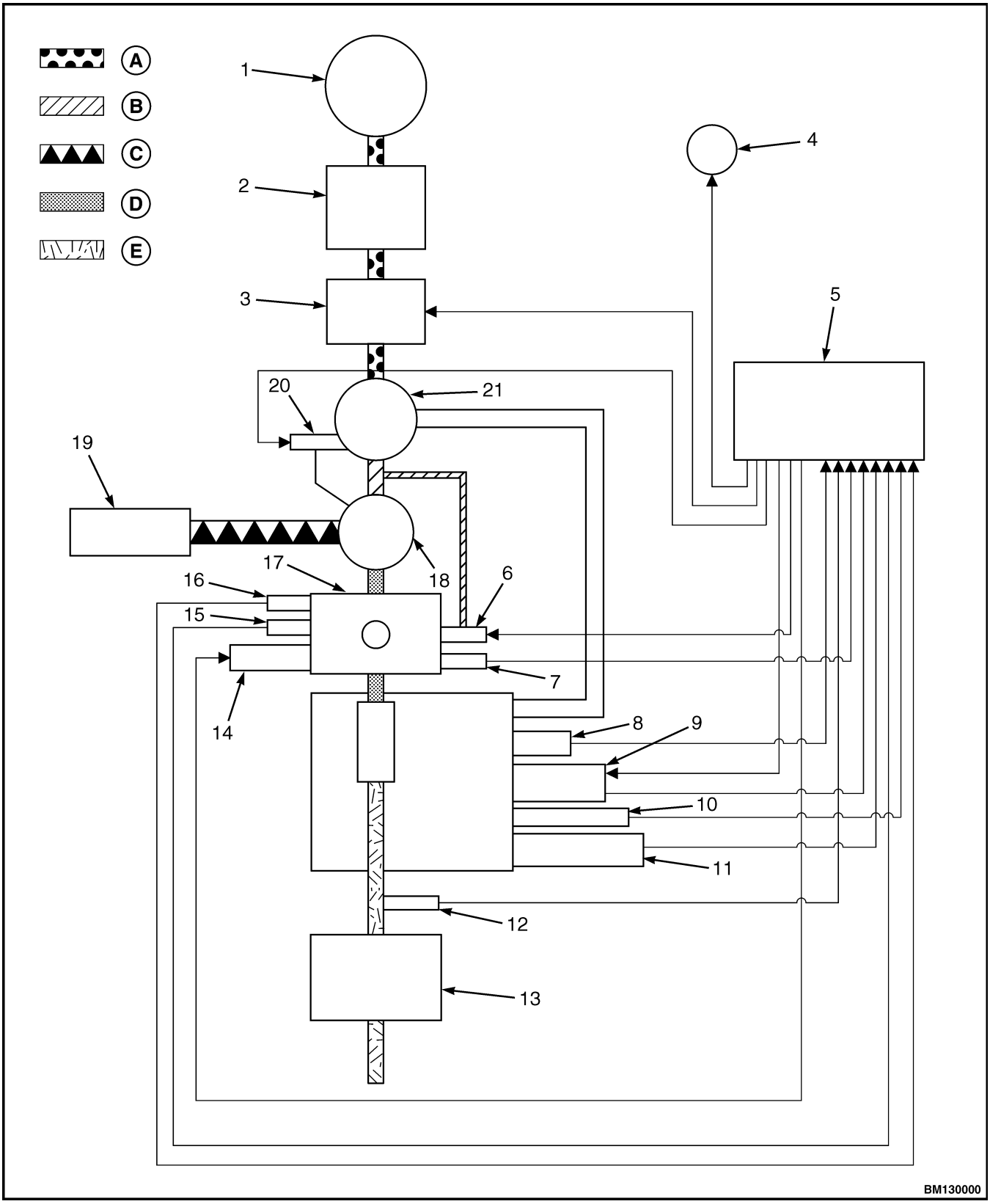
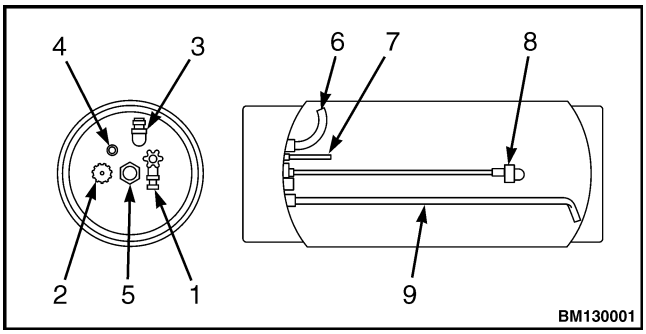


Figure 1. Typical Fuel System Schematic

Legend for Figure 1

A. TANK PRESSURE
B. REGULATED PRESSURE
C. INTAKE AIR
D. AIR/FUEL MIXTURE
E. EXHAUST GASES

1. FUEL CYLINDER
2. FUEL FILTER
3. LPL
4. MALFUNCTION INDICATOR LIGHT (MIL)
5. ELECTRONIC CONTROL MODULE (ECM)
6. FUEL TRIM VALVE (FTV)
7. FOOT PEDAL POSITION SENSOR
8. ENGINE COOLANT TEMPERATURE (ECT) SENSOR
9. DISTRIBUTOR (TIMING)
10. OIL PRESSURE
11. CRANKSHAFT SENSOR
12. HEATED EXHAUST GAS OXYGEN (HEGO) SENSOR
13. THREE-WAY CATALYTIC (TWC) MUFFLER
14. SPEED CONTROL MOTOR
15. TEMPERATURE MANIFOLD ABSOLUTE PRESSURE (TMAP)
16. THROTTLE POSITION SENSOR (TPS)
17. THROTTLE BODY
18. MIXER
19. AIR CLEANER
20. PRESSURE TRIM VALVE (PTV)
21. LOW PRESSURE REGULATOR (LPR)

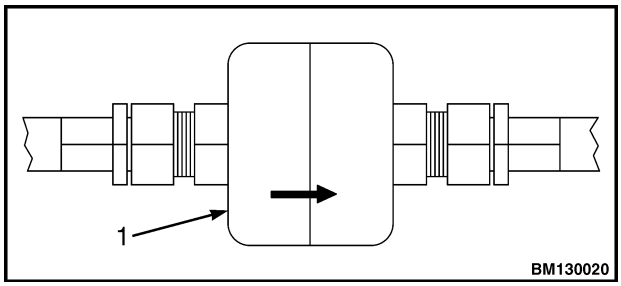


1. LIQUID OUTAGE VALVE WITH QUICK DISCONNECT COUPLING
2. FILLER VALVE
3. PRESSURE RELIEF VALVE
4. LIQUID OUTAGE FILL CHECK VALVE
5. FUEL GAUGE
6. VAPOR WITHDRAWAL TUBE (WHEN APPLICABLE)
7. 80 PERCENT LIMITER TUBE
8. FUEL LEVEL FLOAT
9. LIQUID WITHDRAWAL TUBE

Figure 2. Typical Propane Cylinder

FUEL FILTER

Propane fuel, like all other motor fuels, is subject to contamination from outside sources. Refueling of the equipment's tank and removal of the tank from the equipment can inadvertently introduce dirt and other foreign matter into the fuel system. It is therefore necessary to filter the fuel prior to entering the fuel system components down stream of the tank. An in-line fuel filter has been installed in the fuel system to remove the dirt and foreign matter from the fuel. See Figure 3. The in-line filter is replaceable as a unit only. Maintenance of the filter is critical to proper operation of the fuel system and should be replaced as defined in the **Periodic Maintenance** section for your lift truck. In severe operating conditions, more frequent replacement of the filter may be necessary.



1. FUEL FLOW

Figure 3. In-Line Fuel Filter

LOW PRESSURE LOCK-OFF (LPL)

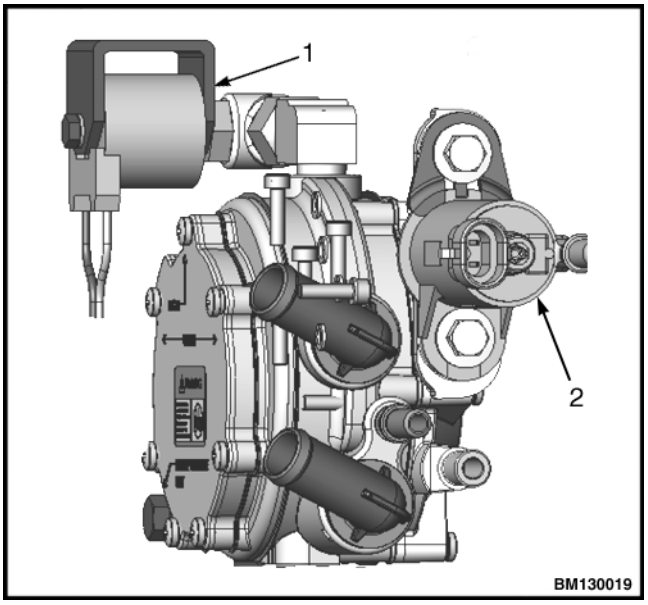
The LPL is an electric lock-off device. The electric lock assembly is a 12-volt normally closed valve. The solenoid is mounted to the valve body. See Figure 4. When energized, the solenoid opens the valve and allows the propane fuel to flow through the device. The valve opens during cranking and run cycles of the engine. The lock-off supply voltage is controlled by the ECM.

LOW PRESSURE REGULATOR (LPR)

CAUTION

The LPR is an emission control device. Components inside the regulator are specifically calibrated to meet the engine emissions requirements and should never be disassembled or rebuilt. If the LPR fails to operate, replace with a HYSTER approved part.

The LPR is a combination vaporizer, pressure-regulating device. The LPR is a negative pressure two-stage regulator that is normally closed when the engine is not running. When the engine is cranking or running, a partial vacuum is created in the fuel line which connects the regulator to the mixer. This partial vacuum opens the regulator, permitting fuel to flow to the mixer. See Figure 4.



1. LPL
2. PRESSURE TRIM VALVE (PTV)

Figure 4. Low Pressure Regulator and LPL

Propane fuel enters the primary port of the LPR and passes through the primary jet and into the primary/exchanger chamber. As the propane passes through the heat exchanger, the fuel expands and creates pressure inside the chamber. The pressure rises as the fuel expands. When the pressure rises above 10.34 kPa (1.5 psi), sufficient pressure is exerted on the primary diaphragm to cause the diaphragm plate to pivot and press against the primary valve pin thus closing off the flow of fuel. This action causes the flow of fuel into the regulator to be regulated. When the engine is cranking, sufficient vacuum will be introduced into the secondary chamber from the mixer, drawing the secondary diaphragm down onto the spring-loaded lever and opening the secondary valve allowing vaporized fuel to pass to the mixer. Increased vacuum in the secondary chamber increases the downward action on the secondary lever causing it to open wider, allowing more fuel to flow to the mixer.

The regulator, utilized on this emission-certified engine, is equipped with a PTV which is directly mounted to the regulator. See Figure 4. This solenoid is a 12-volt normally closed solenoid. The function of this solenoid is to regulate a specific amount of venturi vacuum to the atmospheric side of the secondary diaphragm. By introducing vacuum to the top side of the secondary diaphragm during regulator operation, the amount of fuel being delivered to the mixer can be trimmed or reduced to allow for correction to the air/fuel ratio for closed loop fuel control. The solenoid receives a reference signal from the ECM which causes the solenoid to be pulsed fast or slow depending on the amount of fuel to be trimmed.

AIR FUEL MIXER

CAUTION

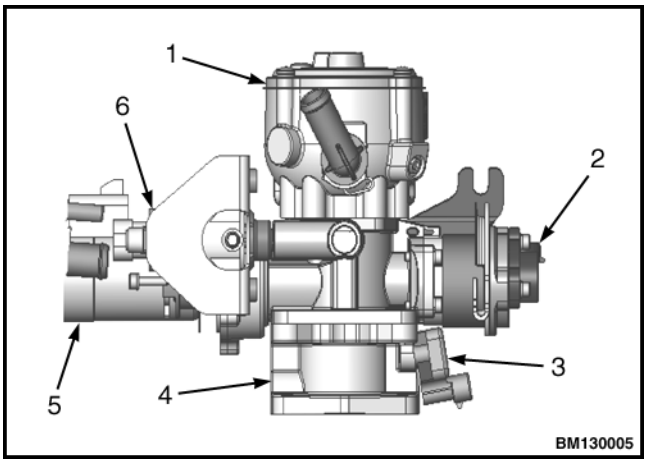
The air/fuel mixer is an emission control device. Components inside the mixer are specifically calibrated to meet the engines emissions requirements and should never be disassembled or rebuilt. If the mixer fails to operate, replace with a HYSTER approved part.

The air valve mixer is an air/fuel metering device and is completely self-contained. The mixer is an air valve design, utilizing a relatively constant pressure drop to draw fuel into the mixer from cranking to full load. The mixer is mounted in the air stream ahead of the throttle control device. See Figure 5.

When the engine begins to crank, it draws in air with the air valve covering the inlet, and negative pressure begins to build. This negative pressure signal is communicated to the top of the air valve chamber through four vacuum ports in the air valve assembly. A pressure/force imbalance begins to build across the air valve diaphragm between the air valve vacuum chamber and the atmospheric pressure below the diaphragm. The air valve vacuum spring is calibrated to generate from 101.6 mm (4 in.) of water column at start to as high as 355.6 mm (14 in.) of water column

at full throttle. The vacuum being created is referred to as air valve vacuum (AVV). As the AVV reaches 101.6 mm (4 in.) of water column, the air valve begins to lift against the air valve spring. The amount of AVV generated is a direct result of the throttle position. At low engine speed, the AVV is low and the air valve position is low, thus creating a small venturi for the fuel to flow. As the engine speed increases, the AVV increases and the air valve is lifted higher, thus creating a much larger venturi. This AVV is communicated from the mixer venturi to the LPR secondary chamber via the low pressure fuel supply hose. As the AVV increases in the secondary chamber, the secondary diaphragm is drawn further down, forcing the secondary valve lever to open wider.

The mixer is equipped with a low speed mixture adjustment, which is retained in a tamper-proof housing. The mixer has been preset at the factory and should not require any adjustment. In the event that the idle adjustment should need to be adjusted, refer to the LPG Fuel System Repair section of this manual.



1. MIXER
2. FOOT PEDAL POSITION (FPP) SENSOR
3. TEMPERATURE MANIFOLD ABSOLUTE PRESSURE (TMAP)
4. ADAPTER TO MANIFOLD
5. GOVERNOR MOTOR
6. FUEL TRIM VALVE (FTV)

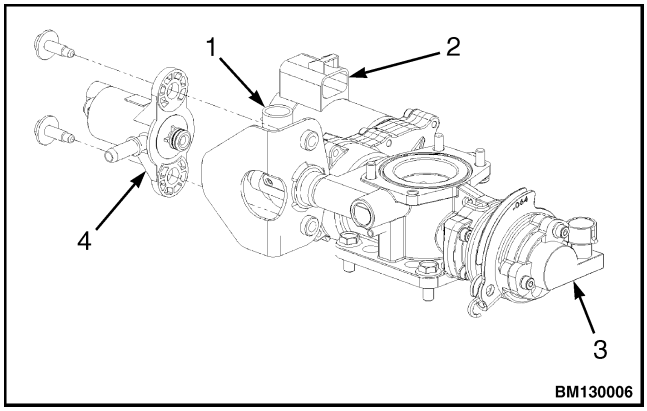
Figure 5. Air/Fuel Mixer

THROTTLE CONTROL DEVICE

Drive By Cable

Engine speed control is maintained by the amount of pressure applied to a foot pedal located in the operator's compartment. A cable is utilized to connect the foot pedal to the throttle shaft in the engine compartment. A coil spring mounted to the pedal and the throttle shaft will keep the throttle shaft in a normally closed position. When the foot pedal is depressed, the throttle shaft is rotated, opening the butterfly in the venturi of the throttle body allowing more air and fuel to enter the engine. When the ECM detects that the engine has reached maximum governed speed or requires adjustment for load, the ECM will correct the blade position by overriding the throttle shaft with the electronic governor.

The air fuel mixer is attached to the throttle control device or throttle body assembly, which is then connected to the intake manifold of the engine. See Figure 6. The throttle body maintains control of engine speed by increasing or decreasing the opening angle of the throttle blade in the throttle body bore, thus increasing or decreasing the fuel air mixture to the engine. The throttle blade shaft is connected to a spring-loaded cable connector which is connected to the foot pedal in the operator's compartment. The shaft incorporates a return spring to insure the blade position returns to idle when the operator removes his foot from the pedal. Also attached to the throttle shaft is a TPS, which provides a signal to the ECM to indicate the throttle blade angle for speed control and load control as well as emission control.



1. THROTTLE POSITION SENSOR (TPS)
2. GOVERNOR MOTOR
3. FOOT PEDAL POSITION (FPP) SENSOR
4. FUEL TRIM VALVE (FTV)

Figure 6. Drive By Cable Throttle body Assembly

Also mounted to the throttle control device is an integrated electronic governor. The throttle control is maintained by a foot pedal located in the operator's compartment and connected to the throttle control device by a cable. The governor is controlled by the

ECM and has no external adjustments. When the ECM determines load adjustment or maximum engine speed has been achieved, the governor overrides the foot pedal and corrects the throttle blade position.

Also mounted on throttle body assembly is the FTV. The FTV is a 12-volt normally closed solenoid valve. During closed loop operation, the ECM may send a reference signal to the FTV to open or close to allow more or less fuel to be introduced below the throttle blade to correct the air fuel mixture for proper emission control.

THREE-WAY CATALYTIC (TWC) MUFFLER

The emission certified engine has been designed and calibrated to meet the emission standards in effect for 2004. To help meet the emission requirements, the vehicle has been equipped with a TWC muffler. See Figure 7. The catalyst muffler is a three-way catalyst, sound damping, and spark arresting unit. Besides controlling the noise created from the combustion process and preventing sparks from escaping from the exhaust system, the most important function is treating the exhaust gases which are created from the combustion process. The TWC consists of a honeycomb coated with a mixture of platinum, palladium, and rhodium. The hot gases flow through the catalyst sections where an oxidation and reduction reactions take place. These chemical reactions reduce the amount of carbon monoxide (CO), hydrocarbon (HC), and nitrogen oxide (NOx) in the engines exhaust. The exhaust gas then flows through the outlet.

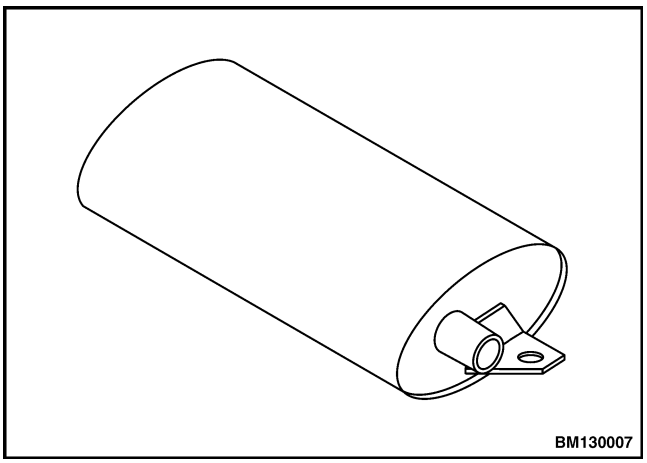


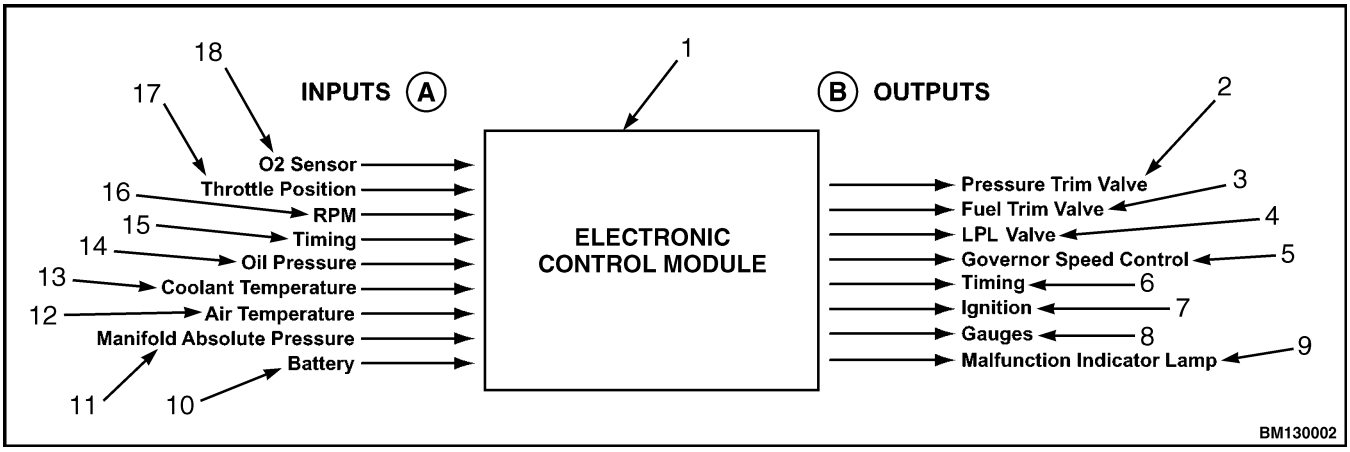
Figure 7. Three-Way Catalytic Muffler

ELECTRONIC CONTROL MODULE (ECM)

To obtain maximum effect from the catalyst and accurate control of the air fuel ratio, the emission certified engine is equipped with an on-board computer or ECM. See Figure 8. The ECM is a 32-bit controller which receives input data from sensors fitted to the engine and fuel system and then outputs various signals to control engine operation.

One specific function of the controller is to maintain closed loop fuel control. Closed loop fuel control is accomplished when the heated exhaust gas oxygen (HEGO) sensor, mounted in the exhaust system, sends a voltage signal to the controller. The controller then calculates any correction that may need to be made to the air fuel ratio. The controller then outputs signals to the PTV or the FTV or both to change the amount of fuel being delivered from the regulator or mixer or to the engine. See Figure 9.

The controller also performs diagnostic functions on the fuel system and notifies the operator of malfunctions by turning on a malfunction indicator light (MIL) mounted in the dash. Malfunctions in the system are identified by a diagnostic code number. In addition to notifying the operator of the malfunction in the system, the controller also stores the information about the malfunction in its memory. A technician can then utilize a computerized diagnostic tool to retrieve the stored diagnostic code and by using the section **Electronic Control Module (ECM) Diagnostic Troubleshooting**, **GM 3.0L and 4.3L EPA Compliant Engines** 2200 SRM 1090, can determine the cause of the malfunction. In the event a technician does not have the computerized diagnostic tool, the MIL light can be used to identify the diagnostic code. By following specific steps, the technician can activate the blink feature and count the number of blinks to determine the diagnostic code number to locate the fault in the system.



A. INPUTS

1. ELECTRONIC CONTROL MODULE (ECM)
2. PRESSURE TRIM VALVE (PTV)
3. FUEL TRIM VALVE (FTV)
4. LPL VALVE
5. GOVERNOR SPEED CONTROL
6. TIMING
7. IGNITION
8. GAUGES
9. MALFUNCTION INDICATOR LAMP (MIL)

B. OUTPUTS

10. BATTERY
11. MANIFOLD ABSOLUTE PRESSURE (MAP)
12. AIR TEMPERATURE (TMAP)
13. COOLANT TEMPERATURE
14. OIL PRESSURE
15. TIMING
16. ROTATIONS PER MINUTE (RPM)
17. THROTTLE POSITION
18. OXYGEN O_2 SENSOR

Figure 8. LPG Electronic Control Module

HEATED EXHAUST GAS OXYGEN (HEGO) SENSOR

CAUTION

The HEGO sensor is an emissions control component. If the HEGO sensor fails to operate, replace only with a HYSTER approved part. The HEGO sensor is sensitive to silicone and silicone-based products and can become contaminated. Avoid using silicone sealers or hoses treated with silicone lubricant in the air stream or fuel supply lines.

The HEGO sensor is mounted in the exhaust system downstream of the engine. The HEGO sensor is used to measure the amount of oxygen present in the exhaust stream and communicate that to the ECM through an electrical signal. The amount of oxygen present in the exhaust stream indicates whether the fuel air ratio is too rich or too lean. If the HEGO sensor signal indicates that the exhaust stream is too rich, the ECM will decrease or lean the fuel mixture during engine operation. If the mixture is too lean, the ECM will make the mixture rich. The ECM continuously monitors the HEGO sensor output. If a rich or lean condition is present for an extended period of time and the ECM cannot correct the condition, the ECM will set a diagnostic code and turn on the MIL light in the dash. See Figure 10.