

PE14-020

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Business Class M2 M2 Driver's
Manual CNG Section

16

Natural Gas Vehicle

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Natural Gas Vehicle

Natural Gas Vehicles, General Information

The vehicle can be equipped with a compressed natural gas (CNG) fuel system, or a liquefied natural gas (LNG) fuel system. CNG is made by compressing natural gas to less than 1% of its volume at standard atmospheric pressure. LNG is created by condensing natural gas into a liquid by cooling it to approximately -259°F (-162°C).

When vaporized at ambient temperatures, natural gas is less dense than air, and it rises and disperses. However, LNG is initially heavier than air due to its cryogenic temperature. When released in large amounts, it may drop or pool on the ground before its temperature rises enough to vaporize. Cold atmospheric conditions may prevent natural gas from dispersing quickly when released in large amounts.

Natural gas is nontoxic, but it can cause asphyxiation if present in very large concentrations.

CNG often contains an odor-producing chemical, while LNG does not have any odor. Users of natural-gas-fueled vehicles should never expect to detect natural gas leaks by scent.

For natural gas to burn, it must first vaporize, then mix with air in the proper proportions (flammable range is 5 to 15% by volume in air), and then be ignited.

A typical natural gas fuel system consists of:

- Fuel supply cylinders that store compressed gas at high pressure (CNG), or a tank that stores liquefied gas at an extremely low temperature (LNG).
- A vaporizer or heat exchanging device that changes LNG to gaseous form (LNG fuel systems only).
- Pressure relief and manual fuel shutoff valves.
- A filling connection with a check valve that prevents the gas from flowing back out of the fuel filling line.
- High-pressure and low-pressure fuel filters.
- A pressure control regulator that reduces the high fuel tank or cylinder pressure to the lower pressure needed for the engine.

- A fuel contents gauge that indicates the fuel supply in the tank or cylinders.

Natural Gas Vehicles, Safety Precautions

DANGER

Natural gas is highly flammable. Failure to observe the following safety precautions could lead to the ignition of the natural gas, which could cause serious bodily injury or death.

Follow these safety precautions when operating or repairing a natural gas vehicle.

- Do not start the engine if a natural gas leak is detected.
- Do not transfer CNG from one vehicle to another, as a buildup of static electricity could cause a spark and ignite the fuel.
- Do not attempt to cut any fuel supply piping components.
- Avoid open flames or sparks near a natural gas vehicle.
- Cover eyes and exposed skin when working on a natural gas fuel system or fueling a natural gas vehicle.
- Permit no smoking or other ignition sources within thirty feet of a natural gas vehicle.
- Have CO₂ fire extinguishers (ABC minimum) located in a highly visible and easily accessible location.
- Use Purple-K powder (PKP) or a similar dry powder to extinguish an LNG fire. Do not attempt use water around an LNG fire.
- Always purge the fuel lines before performing maintenance or repairs on a natural gas fuel system. To purge the lines, close the manual fuel shutoff valve, and start the engine. Let the vehicle idle until the fuel lines are empty and the engine stops.
- Always use a natural gas detector to test the system for leaks, whether an odor is present or not. Routinely inspect the fuel filtering and regulating mechanisms, and the fuel lines. A

bubble solution can be used to pinpoint the exact location of leaks.

- Always tighten fasteners and fuel connections to the required torque specification. Overtightening or undertightening could cause leaks.
- Close the fuel shutoff valve(s) before performing maintenance and repairs.
- Do not store a natural gas vehicle indoors for any extended period of time. Do not bring a natural gas vehicle indoors unless the workshop is equipped with a methane detection and ventilation system.

In Case of Emergency

If a vehicle has sustained damage or a leak has been discovered:

1. Turn the ignition switch off, set the parking brake, and disconnect the battery.
2. Remove all ignition sources from the area surrounding the vehicle.
3. If it is safe to do so, close all fuel shutoff valves.
4. Open the vehicle doors to introduce fresh air.
5. Use a natural gas detector to identify leaks in the fuel system.

Natural Gas Fuel Tank Filling Procedures

CNG Vehicle Fueling

CNG is moved from the fuel station storage tanks to the vehicle cylinders through a metered dispenser. During fueling, as pressure inside of the vehicle cylinders increases, so does the temperature. The dispenser shuts off when it determines the CNG cylinders are full.

CNG fuel cylinders cannot be filled to their full capacity of 3600 psi (24 800 kPa) in cooler weather. Since temperature change causes gas to expand and contract, less pressure in the cylinders on a cold day is equal to the same amount of gas at a higher pressure on a warm day. The fuel station dispenser has a temperature-pressure compensating device, which accounts for ambient temperature during fueling. See [Table 16.1](#) for approximate full cylinder pressures at various temperatures.

CNG Temperature/Pressure Compensation Values		
Temperature: °F (°C)	Fill Station Pressure Set Point	
	3000 psi (20 684 kPa) Set Point	3600 psi (24 821 kPa) Set Point
100 (37.8)	3415 (23 546)	4086 (28 172)
90 (32.2)	3276 (22 587)	3909 (26 952)
80 (26.7)	3138 (21 636)	3754 (25 883)
70 (21.1)	3000 (20 684)	3600 (24 821)
60 (15.6)	2861 (19 726)	3445 (23 752)
50 (10)	2723 (18 774)	3288 (22 670)
40 (4.4)	2584 (17 816)	3131 (21 587)
30 (-1.1)	2446 (16 865)	2973 (20 498)
20 (-6.7)	2307 (15 906)	2814 (19 402)
10 (-12.2)	2169 (14 955)	2655 (18 306)
0 (-17.8)	2031 (14 003)	2495 (17 202)
-10 (-23.3)	1893 (13 052)	2336 (16 106)
-20 (-28.9)	1755 (12 100)	2180 (15 031)
-30 (34.4)	1616 (11 142)	2024 (13 955)
-40 (-40)	1477 (10 184)	1868 (12 879)

Table 16.1, CNG Temperature/Pressure Compensation Values

Use the following steps to fuel a CNG vehicle.

1. Shut down the engine and apply the parking brake.

IMPORTANT: Close all windows and doors during the fueling process. Keeping windows and doors closed allows for easier leak detection inside the cab after fueling.

WARNING

Natural gas fuel tanks, lines, and valves are always pressurized. Always observe safety precautions. Failure to do so could lead to loss of control over a filling hose or to ignition of the natural gas, which could cause serious bodily injury, death, or severe property damage.

2. Ensure all fuel cylinder shutoff valves are open. See [Fig. 16.1](#).
3. Ensure the vehicle fuel system main shutoff valve is open.
4. Open the CNG fuel panel access door and remove the dust cap from the vehicle fuel fill port.

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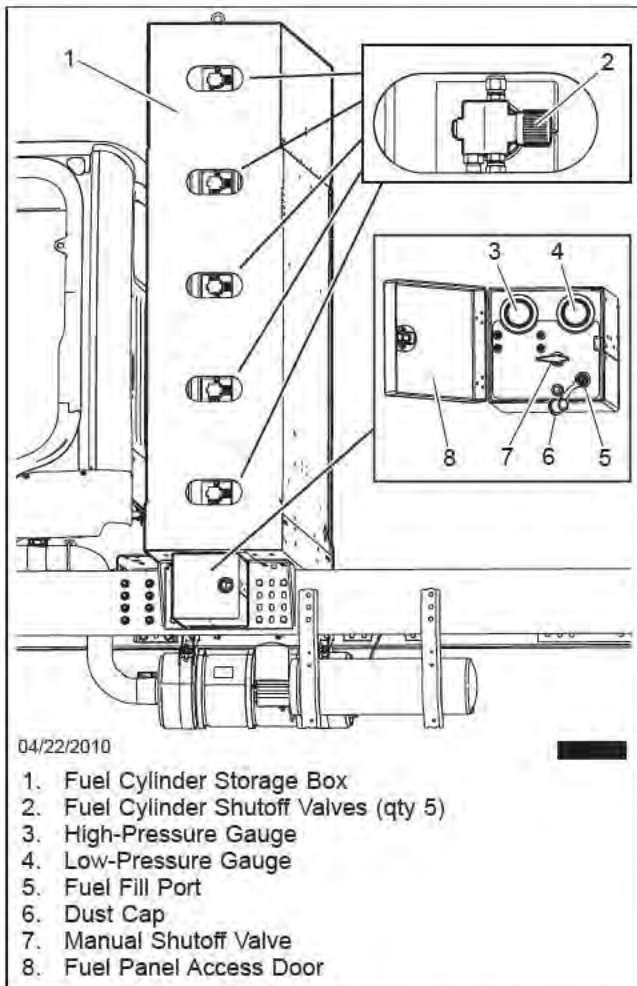


Fig. 16.1, CNG Fuel Cylinder Storage Box (5-cylinder system shown)

5. Ensure the O-ring is present inside the fuel fill port. If the O-ring has been dislodged or is missing, the station dispensing nozzle will not connect securely to the fill port.
6. Turn the selector knob on the service pump to the VENT position, if equipped.
7. Connect the quick coupling on the dispensing nozzle securely to the vehicle fuel fill port.
8. Turn the selector knob on the service pump to the FILL position, if equipped.

IMPORTANT: If at any time the service pump or vehicle begins to vent CNG uncontrollably, notify a station attendant or activate the service sta-

tion emergency shut-off switch to cease the flow of CNG.

9. Switch on the service pump. A slight hissing noise may be heard as the fuel cylinders fill.
10. Watch the pressure gauge on the service pump. When the gauge reads approximately 3600 psi (24 800 kPa), or when the fill pressure stops climbing, the CNG cylinders are full. The service pump will shut itself down automatically. See **Table 16.1** for pressure compensation values based on ambient temperatures.
11. Move the selector knob on the service pump to the VENT position, if equipped. A short hiss will be heard as a small amount of natural gas is vented into the hose.

! WARNING

Do not attempt to remove the fill station nozzle from the tank fill fitting until venting of pressure is noted. If no venting occurs, ask for assistance from the station attendant. Removing an un-vented coupling could result in an uncontrolled hose, which could lead to property damage or personal injury.

12. Remove the station dispensing nozzle from the vehicle fill port.
13. Install the dust cap on the vehicle fuel fill port and close the fuel panel access door.

LNG Vehicle Fueling

The LNG fuel tank is designed to be filled from any LNG fuel source that has a 100 micron or finer fuel filter and a fuel delivery pressure between 120 and 225 psi (827 and 1551 kPa).

The LNG fuel tank is designed to be top-filled through a single hose with no vent return. As cold LNG is sprayed into the vapor space of the tank, the cold liquid condenses the vapor and creates space for itself inside the tank, eliminating any need to vent during the filling process.

The LNG tank is equipped with a small internal ullage tank for vapor space, which allows for fuel expansion and increases vehicle standby time. When an LNG tank is full, fuel can continue to flow into the ullage tank. However, if the ullage tank is completely filled during fueling, standby time will be reduced to

zero and the primary relief valve will open almost immediately after fueling, allowing excess LNG vapor to escape. If fueling is stopped when the ullage tank is empty (i.e., the fuel tank has sufficient vapor space to accommodate fuel expansion due to temperature increase), the vehicle will have approximately one week of standby time before venting will occur.

Use the following steps to fuel an LNG vehicle.

1. Shut down the engine and apply the parking brake.

IMPORTANT: Close all windows and doors during the fueling process. Keeping windows and doors closed allows for easier leak detection inside the cab after fueling.

WARNING

Liquefied natural gas is a cryogenic liquid stored at approximately -259°F (-162°C). Cryogenic burns can be caused by coming into contact with the pressurized liquid stream, or by coming into contact with fuel system components that have been cooled to cryogenic temperatures. Always wear gloves and a face shield, and cover exposed skin when fueling.

2. Remove the fuel fill fitting dust cap. See [Fig. 16.2](#).
3. Using compressed air, remove any dirt, debris, or water that may have collected in the fuel fill fitting and the station dispensing nozzle. Contaminants in the fuel system can cause drivability problems.

WARNING

Natural gas fuel tanks, lines, and valves are always pressurized. Always observe safety precautions. Failure to do so could lead to loss of control over a filling hose or to ignition of the natural gas, which could cause serious bodily injury, death, or severe property damage.

4. Connect the station fueling nozzle to the tank fuel fill fitting.
5. Connect an electrical ground clamp and cable to the fuel tank.

IMPORTANT: An LNG tank which is first installed, or is on a vehicle that has not been op-

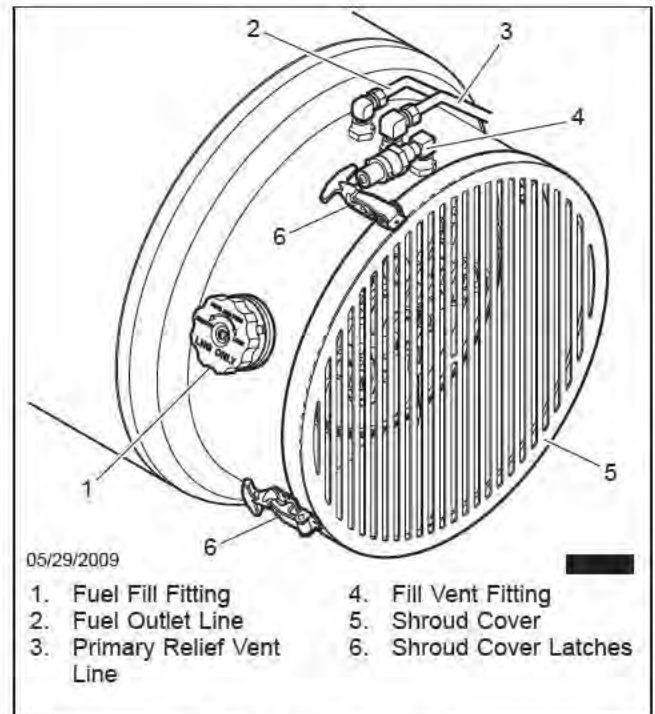


Fig. 16.2, LNG Fuel Tank

erated in approximately ten days, is considered to be a hot tank. When fueling a hot tank, LNG entering the tank will immediately vaporize, causing tank pressure to spike above 250 psi (1724 kPa) and automatically shutting down the station fuel pump. To prevent the pump from shutting down, connect a vent line to the fill vent fitting on the LNG tank to capture escaping vapor, then open the shroud cover and open the vapor shutoff valve ([Fig. 16.3](#), Item 2).

6. Open the station's fill valve, if equipped, and start fueling. Monitor the flow or line pressure as filling progresses. When filling begins, line pressure will spike quickly until the vehicle tank cools down. The flow and pressure will then remain stable during the remainder of the filling procedure.

IMPORTANT: When fueling a hot tank, initially put 5 to 10 gallons (19 to 37 liters) of LNG in the tank and manually stop the fueling process. Drive the vehicle for 15 to 20 minutes to cool the tank and reduce tank pressure, then continue fueling the tank to full.

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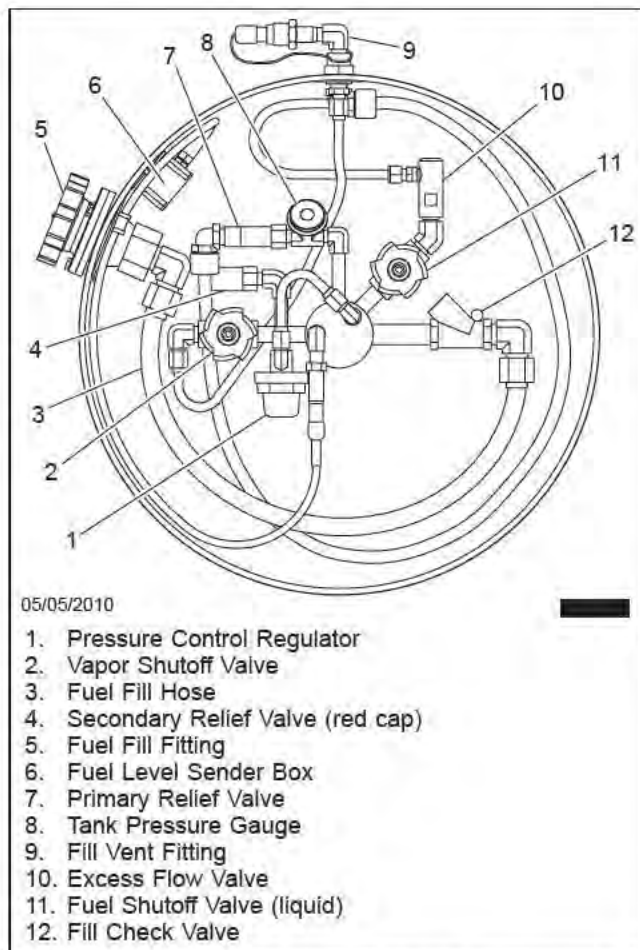


Fig. 16.3, LNG Fuel Tank Plumbing Components

7. When the tank is full, the line pressure will rapidly spike and the flow rate will fall. When a pressure rise or flow rate drop is observed, close the station's fill valve, if equipped.

NOTE: Do not over-fill an LNG tank. If the ullage tank is completely filled during fueling, tank standby time will be reduced to zero and the primary relief valve will open almost immediately after fueling.

8. Disconnect the station hose from the tank fuel fill fitting.
9. Disconnect the electrical ground clamp and cable from the fuel tank.
10. Install the dust cap on the tank fuel fill fitting.

Natural Gas Detection System

A gas detection system is used in all Daimler Trucks natural-gas-fueled vehicles. This system has a sensor in the engine compartment and one in the cab, both situated in high areas to detect natural gas buildup as a result of leaks.

The AMGADS III Plus is a natural gas detection system. This device is meant to serve as a supplemental warning only. It is not intended to replace standard safety practices that should be conducted around flammable gases.

IMPORTANT: To function properly, the gas detection system must be powered at all times. The gas detection system is directly powered by the batteries, and can only be powered off by disconnecting the batteries. When servicing a natural-gas-fueled vehicle, disconnect the batteries only when necessary, and do not leave the batteries disconnected for extended periods of time.

The lower flammability limit (LFL) is the smallest amount of the gas that supports a flame when mixed with oxygen and ignited. Zero percent (0%) LFL indicates a gas-free atmosphere. One hundred percent (100%) LFL indicates that gas concentration has reached its lower flammability limit (5% gas in air by volume). The red warning light and audible alarm located in the overhead console activate when a sensor detects gas fumes in concentrations above 50% LFL, and should allow ample time to utilize safety procedures. However, individuals with special needs should review the system with a professional safety engineer.

Alarm Procedure

Before operating the vehicle, the driver must be familiar with the procedures as shown on the interior sticker on the overhead panel (**Fig. 16.4**) and the exterior sticker on the door (**Fig. 16.5**).

IMPORTANT: If an audible alarm activates, do not operate any electrical switch, including lights. Avoid causing sparks and stay away from arcing switches and equipment. Do not use a telephone, including cellular phones or any types of portable communication or electronic devices that have a battery.



Fig. 16.4, Interior Warning Sticker



Fig. 16.5, Exterior Warning Sticker

If the vehicle is in motion when the audible alarm activates, bring it to a safe stop, shut down the engine, and exit the vehicle. *Do not open the hood.*

If outside the vehicle when the audible alarm activates, *do not open the cab door or hood.*

In the event of an audible alarm, immediately follow these procedures, as allowed by conditions:

1. Immediately shut off all engines. Extinguish any cigarettes, pilot lights, flames, or other sources of ignition in the area and adjacent areas.
2. Manually close all fuel shutoff valves, including those on the LNG tank or CNG cylinders.
3. If the vehicle is indoors (as in a service shop), immediately open windows and doors to provide extra ventilation to the area. Do not start the engine or any other type of equipment until the gas leak is corrected and the area cleared of natural gas.
4. Evacuate the area.
5. Check the fuel lines, LNG tank/CNG cylinders, and fittings to locate the leak. After the area is cleared of natural gas and the alarm is no longer active, have the vehicle inspected by a qualified technician.

IMPORTANT: Do not consider the area clear until all alarm indicators are off, and the alarm panel light returns to green.

Sensors

Gas detection sensors are located on the cab overhead console and in the engine compartment on the frontwall. The sensors are located in high areas, where rising gas vapors will pass by or accumulate.

If the system detects that one of the sensors has been disconnected or has malfunctioned, the sensor fault light for that zone will illuminate. A failed sensor may trigger and lock on an alarm. If a fault condition or locked alarm continues after the sensor's connection and wiring integrity has been verified, replace the sensor.

The sensors are sensitive to all hydrocarbon vapors. An alarm may be triggered by the use of chemicals such as cleaners, paint, polish, lacquer, gasoline, silicone, silicone spray, or other harsh chemicals. The sensors will also detect hydrogen fumes from an overcharged battery. If a sensor sends an alarm, but no gas fumes are present, check for recent use of chemicals or a battery charger.

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NOTICE

Silicone-based chemicals and cleaners will permanently disable the sensors. When cleaning the vehicle, cover the sensors with a plastic covering. Keep the sensors covered until the area has been cleared of any cleaning fumes.

Harsh chemicals and extremely high temperatures may damage the sensor.

Puncture of or damage to the seal located inside the sensor housing will significantly shorten the sensor life.

Frequent exposure to high concentrations of gas will accelerate sensor deterioration.

Overhead Console

The overhead console consists of an alarm panel on the right side and the control module on the left side.

The alarm panel has a green light, a red light, a buzzer, and a sensor. See [Fig. 16.6](#). It is located within view from outside of the vehicle. The large green light is continuously illuminated during normal operating conditions.

Before entering the vehicle, always verify that the green light is illuminated. If the green light is not illuminated, do not enter the vehicle. Complete the alarm procedure previously outlined.

The alarm panel meets the California Highway Patrol Title 13-2008 and NFPA 52 2010 requirements. All drivers and technicians using it should be trained regarding the red and green lights, and the audible warning.

The control module, located on the left side of the overhead console, contains the status lights and control buttons for the system. The areas that the sensors monitor are defined as Zone 1 (cab) and Zone 2 (engine compartment). The control module has lights assigned to each zone that will illuminate if a sensor detects a trace level leak (between 20% and 30% LFL), a significant level leak (above 50% LFL), or if a sensor is disconnected or malfunctioning.

- **Trace Level:** If either sensor detects gas fumes at a concentration greater than 20% to 30% LFL (1% gas in air by volume), the amber light next to the *Trace* indicator for that zone will flash. There is no buzzer alarm for a trace

level detection, and the large green light on the alarm panel will remain illuminated.

- **Significant Level:** If either sensor detects gas fumes at a concentration greater than 50% to 60% LFL (2.5% gas in air by volume), the small red light next to the *SIGNIFICANT* indicator for that zone will flash. After approximately 15 seconds, the large green light on the alarm panel will switch off, the red light will illuminate, and the buzzer will sound. All alarm indicators will remain on as long as fumes are detected.
- **Sensor Fault:** If the system detects that either of the sensors has been disconnected or has malfunctioned, an amber light next to the *Sensor Fault* indicator for that zone will illuminate.

The control module also has buttons used to test or reset the the control module after an alarm. Red lights next to each button indicate when they are engaged.

- **Shutdown Reset:** If an alarm has been activated and the *Relay Engaged* light is illuminated, the *Shutdown Reset* button will reset the internal relay. Press the *Shutdown Reset* button only after the gas has cleared, the buzzer has turned off, and the alarm panel light has returned to green.
- **Push To Silence:** If an alarm has been activated, the *Push To Silence* button will silence the buzzer.

See [Table 16.2](#) for the functions of all lights and buttons on the overhead console.

Testing

Daimler Trucks North America strongly recommends that all operators follow California Code of Regulations (CCR) inspection requirements, regardless of where the vehicle is operated. Per Title 13 CCR § 935 (2), gas detection systems should be tested three times per calendar year at equal intervals. The testing procedure should simulate the same operating environment in which the vehicle is used, with the same gaseous fuel.

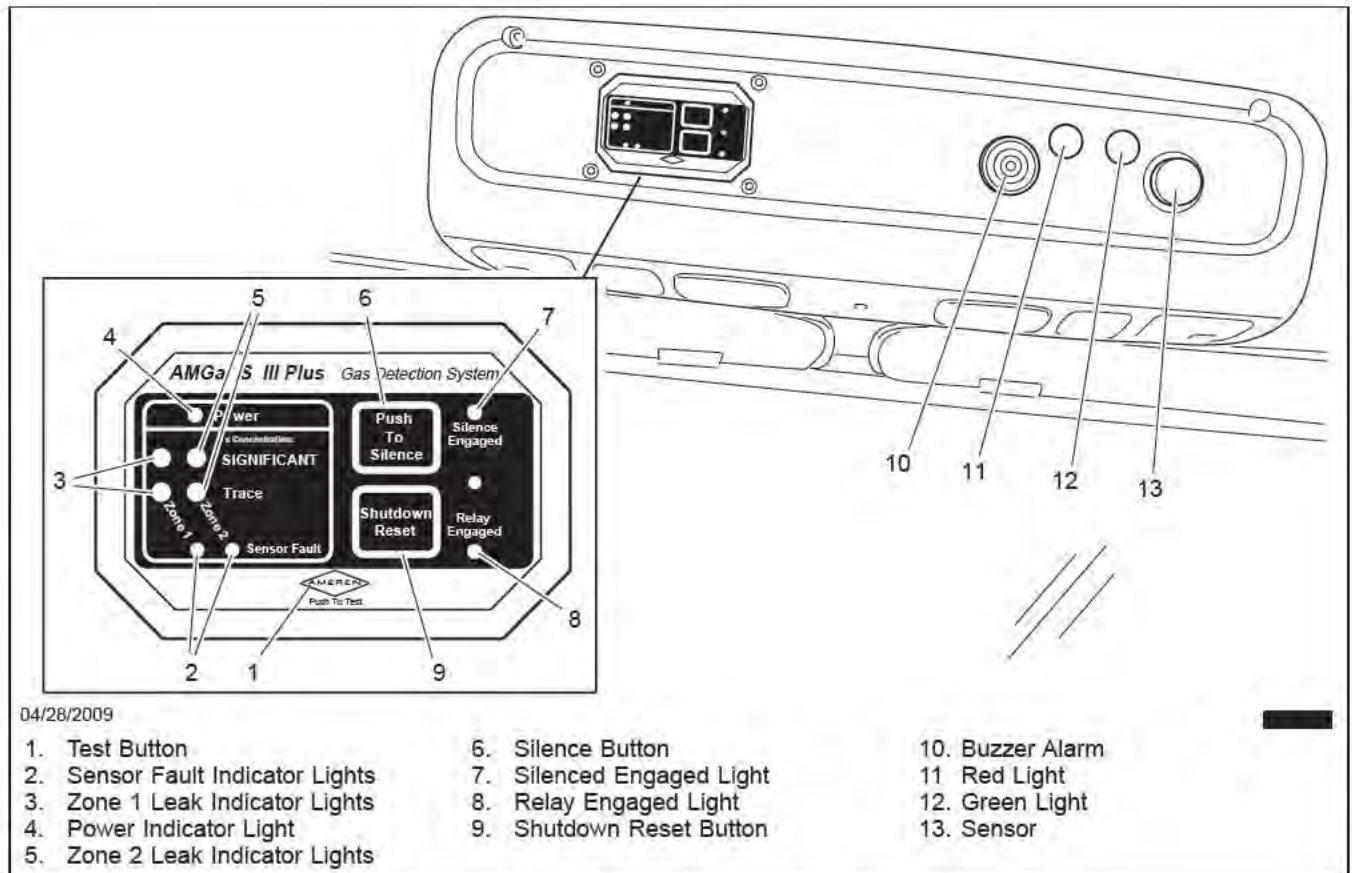


Fig. 16.6, AMGADS III Plus Overhead Console

Control Module Functions			
Item	Display	Function	Action Required
Green Power Light	Illuminated	System is on.	None required.
	Unlit	Detection system is not functioning.	Ensure the batteries are connected and replace any blown fuses. If the gas detection system is still not functioning, replace the system immediately.
SIGNIFICANT Gas Concentration Lights	Red (illuminated)	Dangerous gas concentration detected.	Suspend vehicle operation immediately and follow alarm procedures.
Trace Gas Concentration Lights	Amber (flashing)	Minor gas concentration detected.	Use caution and monitor the system.
Sensor Fault Lights	Off	Sensor is functioning properly.	None required.
	On	Sensor has malfunctioned.	Replace the sensor immediately.

Natural Gas Vehicle

Control Module Functions			
Item	Display	Function	Action Required
Shutdown Reset Button	—	Resets the system after an alarm activation.	Press to reset the system only after the gas has cleared, the buzzer has turned off, and the alarm panel light has returned to green.
Relay Engaged Light	On	Relay is engaged and test or alarm is being cleared.	Press the <i>Shutdown Reset</i> button.
	Off	Normal condition.	None required.
Test Button	—	Tests the overhead console operation and circuitry.	Press and hold for one minute to activate a test of all overhead console components.
Silence Button	—	Silences the alarm buzzer.	Press to silence the alarm buzzer.
Silence Engaged Light	On	Indicates the buzzer is active but silenced.	Suspend vehicle operation immediately and follow alarm procedures.
	Off	Normal condition.	None required.

Table 16.2, Control Module Functions

Test results validating the performance of the gas detection system within the parameters established by the component manufacturer and NFPA 52 2010 should be maintained as a permanent part of the vehicle service records. Use of alcohol, propane, and other harsh liquids or gases are not acceptable methods for testing.

Always test the system and sensors after any component has been replaced, or if the vehicle has been involved in an accident or fire. Ensure that the gas detection system is wired directly to the battery.

It is recommended that the highest level of safety validation be utilized if there are multiple validation requirements in the state or locality where the vehicle is operated or domiciled.

Overhead Console Test

Press and hold the *Push To Test* button for one minute. The system will proceed with a self-diagnostic test that will include illumination of the *Trace* and *SIGNIFICANT* gas concentration lights, and the sensor fault lights. Verify the large red light and buzzer activate, and that all lights illuminate or flash to ensure that all bulbs are operational.

Sensor Test

The gas detection system sensors must be tested using certified test gas, which can be purchased as part of a test kit. Testing with alcohol or heavy gases

such as butane or propane does not satisfy CCR § 935 (2) or NFPA 52 regulations.

Expose each sensor to certified test gas for at least thirty seconds. The system will proceed through the alarm procedure consistent with a significant leak and the buzzer will sound after approximately fifteen seconds. If a sensor fails to respond after exposure to the test gas, replace the sensor.

Natural Gas Engine Starting

NOTE: Before starting the engine, read [Chapter 3](#) for detailed information on how to read the instruments and [Chapter 4](#) for detailed information on how to operate the controls. Read the operating instructions in the engine manufacturer's operation manual before starting the engine.

1. Before engine start-up, complete the engine pre-trip and post-trip inspections and maintenance procedures in [Chapter 11](#).
2. Ensure the fuel shutoff valve is open.
3. Set the parking brake.
4. Ensure that the transmission shift control is in Neutral (N), Park (P), or the Park Brake (PB) position.

- Without starting the engine, turn the ignition switch to the ON position (**Fig. 16.7**). The electronic gauges on the instrumentation control unit (ICU) will complete a full sweep of their dials, the warning and indicator lights will illuminate, and the buzzer will sound for three seconds.

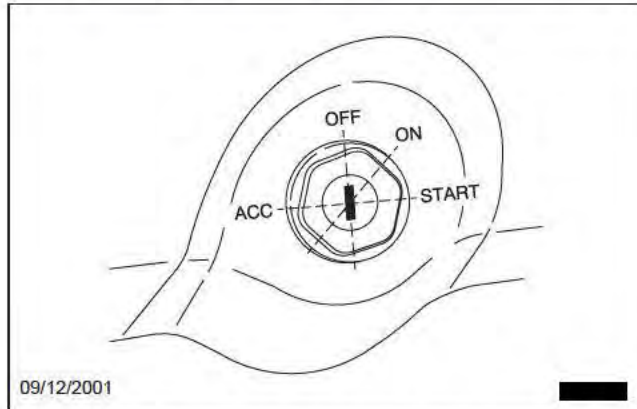


Fig. 16.7, Ignition Switch Positions

- Turn the ignition switch to the START position.
Press down on the clutch pedal, if equipped, but do not press down on the accelerator pedal.
Release the key the moment the engine starts.
- Bring the engine up to operating speed gradually as it warms up and develops stable oil pressure. If the vehicle has not been operated previously in a 24-hour period, allow the vehicle to idle for five minutes.

NOTICE

Do not rev the engine if the oil pressure gauge indicates no oil pressure. Shut down the engine within approximately ten seconds to avoid engine damage.

- Check the oil pressure gauge for any drop in lubricating oil pressure or mechanical malfunction in the lubricating oil system.

Major Repair and Replacement of Natural Gas Components

If a natural-gas-fueled vehicle is involved in an accident, remove the fuel tank or cylinders from service and have them inspected by a qualified technician.

Replace any leaking or damaged fuel tanks/cylinders and fuel lines; repair or replace leaking or damaged fittings. Install parts and components in accordance with the manufacturer's instructions.

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DATA TO ODI

NO LETTER

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Business Class M2 Workshop
Manual CNG Section

General Description

IMPORTANT: The compressed natural gas (CNG) fuel system should be routinely inspected for gas leakage. Use a natural gas detector to check fuel cylinders, fuel filtering and regulating mechanisms, and fuel lines. Replace leaking fuel cylinders; repair or replace any lines, devices, or connections that are leaking.

CNG is made by compressing natural gas to less than 1% of its volume at standard atmospheric pressure. When vaporized at ambient temperatures, natural gas is less dense than air, and it will rise and disperse. Cold atmospheric conditions may prevent natural gas from disbursing quickly when released in large amounts.

Natural gas is nontoxic, but can cause asphyxiation at high enough concentrations simply by excluding adequate oxygen to sustain life.

Commercial CNG normally contains an odor-producing chemical. However, a natural gas detector is recommended for leak checking.

For natural gas to burn, it must first vaporize, then mix with air in the proper proportions (flammable range is 5 to 15% by volume in air), and then be ignited.

The CNG fuel system consists of:

- Fuel cylinders that store CNG at high pressure
- Pressure relief and manual fuel shutoff valves
- A filling connection with a check valve that prevents the gas from flowing back out of the fuel filling line
- A high-pressure fuel filter
- A pressure control regulator that reduces the high fuel cylinder pressure to the lower pressure needed for the engine
- A gas-air mixer to produce a flammable mixture for the engine
- A dash-mounted fuel contents gauge that indicates the available fuel supply in the cylinders

Related Information and Websites

Detailed CNG fuel system repair, replacement, and troubleshooting information can be obtained from the fuel system manufacturer.

Agility Fuel Systems
1815 E Carnegie Avenue
Santa Ana, CA 92705
949-267-7738

www.agilityfuelsystems.com

Agility Customer Support, 949-267-7745.

Information about Cummins CNG engines can be accessed at: Cummins Westport <http://www.cumminswestport.com>

The following documents and websites provide additional information about CNG and CNG fuel systems:

- NFPA 52 ***Vehicular Gaseous Fuel Systems Code, 2010***: www.nfpa.org
- Society of Automotive Engineers ***Recommended Practice for Compressed Natural Gas Vehicle Fuel***: standards.sae.org/j1616_199402/
- Compressed Gas Association: www.cganet.com

Safety Precautions

WARNING

Compressed natural gas is highly flammable. Failure to observe the following precautions could lead to the ignition of the natural gas, which could cause severe property damage, bodily harm, or death.

Whenever gas is smelled, immediately shut off all engines and ignition sources. Avoid causing sparks, and stay away from arcing switches and equipment. Extinguish cigarettes, pilot lights, flames, and other sources of ignition in the area and adjacent areas. Immediately provide extra ventilation to the area. Do not start any equipment until the gas leak is corrected and the area cleared of natural gas.

Periodic inspections of the compressed natural gas (CNG) fuel cylinders are required by law to ensure continued safety. Each fuel cylinder should be visually inspected at specified intervals for external damage and deterioration. See the *Business Class M2 Maintenance Manual* for inspection schedule information.

If a cylinder receives an impact or has deep scratches or gouges, it should be inspected before refilling. The inspection should be performed by a qualified person, in accordance with the manufacturer's established inspection criteria and Compressed Gas Association procedures.

Always use a natural gas detector to check for leaks.

Servicing Precautions

Observe the following safety precautions when servicing CNG-powered vehicles:

- Always purge the fuel lines before performing maintenance or repairs on a CNG fuel system. Do not transfer CNG from one vehicle to another, as a buildup of static electricity could cause a spark and ignite the fuel.
- Only vent CNG outdoors in a safe location.
- Close the fuel cylinder shutoff valves before performing maintenance and repairs. Open the valves only if CNG is needed to operate the engine or to check for leaks.

- Repair work on a CNG fuel system should be performed only by qualified technicians trained in automotive CNG system repair.
- Always tighten fasteners and fuel connections to the required torque specification. Overtightening or undertightening could cause leaks.
- Cover eyes and exposed skin when working on a CNG fuel system or fueling a CNG vehicle.

Workshop Precautions

Do not store a CNG vehicle indoors for any extended period of time.

Observe the following safety precautions when CNG vehicles are inside a workshop:

- Use only safety fluorescent extension shop lights.
- Ensure the shop ceiling is equipped with a vent system that will allow gas to escape and dissipate.
- Ensure the shop is equipped with an alarm system that activates when gas concentration in the air becomes dangerous.
- Have CO₂ fire extinguishers (ABC minimum) located in a highly visible and easily accessible location.
- Permit no smoking or other ignition sources within thirty feet of a CNG vehicle.
- Avoid open flames or sparks near a CNG vehicle.
- Close the fuel cylinder shutoff valves when storing the vehicle inside. Open the valves only if CNG is needed to operate the engine or to check for leaks.

Major Repair and Replacement of Parts

Replace any leaking or damaged fuel cylinders and fuel lines; repair or replace leaking or damaged fittings. Install parts and components in accordance with the manufacturer's instructions.

Any and all replacement parts (valves, fittings, hoses, etc.) of the CNG fuel system must be designed specifically for CNG automotive use, and must be offi-

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cially approved and rated for the pressures and conditions that pertain.

Gas Detection System

A gas detection system is used in all Daimler Trucks CNG-fueled vehicles. The system has a sensor in the engine compartment and one in the cab, both situated in high areas to detect natural gas buildup as a result of leaks. The system is meant to serve as a supplemental warning only. It is not intended to replace standard safety practices that should be conducted around flammable gases.

IMPORTANT: To function properly, the gas detection system must be powered at all times. The gas detection system is directly powered by the batteries, and can only be powered off by disconnecting the batteries. When servicing a natural-gas-fueled vehicle, disconnect the batteries only when necessary, and do not leave the batteries disconnected for extended periods of time.

Venting



WARNING

Compressed natural gas is highly flammable. Do not attempt to transfer compressed natural gas (CNG) from one vehicle to another, as a buildup of static electricity could cause a spark and ignite the fuel, which could cause bodily injury, death, or severe property damage.

IMPORTANT: Only vent compressed natural gas (CNG) outdoors in a safe location.

The fuel cylinder shutoff valves are installed in line from top to bottom. Closing a fuel cylinder shutoff valve will cut off the flow of CNG from that cylinder and all of the fuel cylinders positioned above it in the storage box.

Compressed natural gas can be vented from the fuel cylinders in two ways.

- Run the engine until it stops.
- Open the CNG bleed valve on the manifold.

If only one cylinder needs to be purged, close the fuel shutoff valves on the fuel cylinders positioned above it. Then, either run the engine until the cylinders are empty and the engine stops, or open the bleed valve and allow the CNG to vent. At this time, all CNG in the venting cylinder and the cylinders in line below it will have vented.

CNG Fuel Tank Removal and Installation

⚠ WARNING

Compressed natural gas is highly flammable. Refer to the safety precautions listed in Subject 100 before servicing the vehicle. Failure to observe these precautions could lead to the ignition of the natural gas, which could cause severe bodily injury, death, or property damage.

NOTE: The tanks can be removed with CNG present in the tanks. Tanks must be stored outdoors, or in an approved facility with proper ventilation, and a natural gas safety monitoring system.

Back-of-Cab-Mounted Tank Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brakes. Chock the tires.
2. Depressurize the CNG system. Follow the instructions in [Subject 110](#).

IMPORTANT: Some residual pressure and gas from the low-pressure side of the system may escape when loosening the fittings. Be prepared for this, and observe all safety precautions.

NOTE: The fuel management module (FMM), coolant hoses, natural gas fuel lines, and wire harnesses are located in the lower area of the cabinet on vehicles with only a back-of-cab installation. See [Fig. 1](#).

3. Disconnect CNG fuel lines.
4. Cap or plug all open fuel lines and fittings to prevent system contamination.
5. Position the lifting device as needed and connect the chain or sling to the eyelets on the top of the cabinet. Apply enough pressure to prevent the cabinet from tipping when loosened.
6. Remove the mounting bracket bolts. See [Fig. 2](#).
7. Using safe lifting procedures with a forklift or hoist, lift the tank up off the frame rails and out or backwards to clear the chassis.

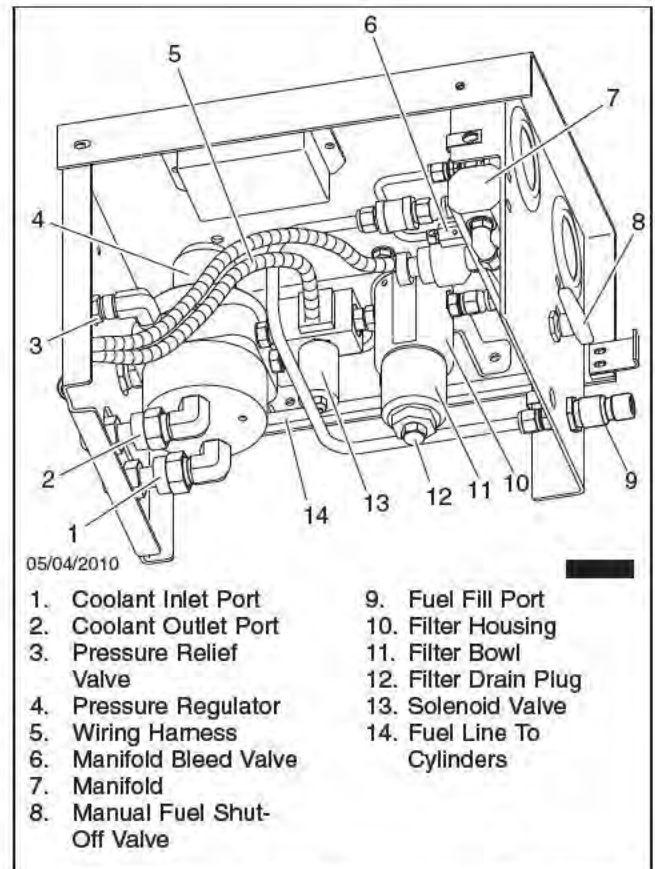
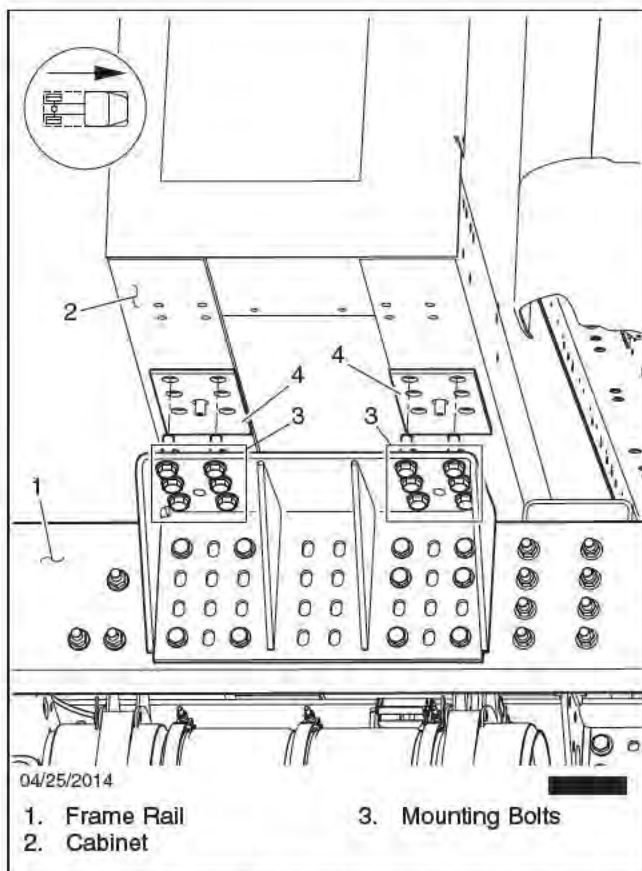


Fig. 1, Back-of-Cab Plumbing and Wiring

Back-of-Cab Mounted Tank Installation

1. Using an appropriate lifting device, position the cabinet on the frame rails and align the mounting bracket holes on the cabinet with the holes in the mounting brackets on the frame rails.
2. While still supported with the lifting device, install the mounting bolts with washers from the bottom of the cabinet. See [Fig. 2](#). Tighten the nuts 160 lbf-ft (217 N-m).
3. Remove lifting device.
4. Connect the coolant hoses.
5. Connect the CNG fuel lines. Tighten the fittings to the specifications shown in [Table 1](#).
6. Connect the wiring harnesses.
7. Secure any mounting that was removed.

CNG Fuel Tank Removal and Installation**Fig. 2, Back-of-Cab Cabinet Installation**

8. Pressurize the system.
9. Check for leaks per the manufactures specifications. Repair any leaks as needed.

⚠ WARNING

Compressed natural gas is highly flammable. Refer to the safety precautions listed in Subject 100 before servicing the vehicle. Failure to observe these precautions could lead to the ignition of the natural gas, which could cause severe bodily injury, death, or property damage.

Welding

IMPORTANT: Follow all local, state, and federal guidelines regarding usage and venting of compressed natural gas (CNG).

1. Park the vehicle on a level surface, shut down the engine and set the parking brake. Chock the tires.
2. Close the CNG fuel cylinder shutoff valves. See Fig. 1.
3. Start the engine and let it idle until the fuel lines are empty and the engine stops. The gauges on the fuel panel should now read at or near 0 psi (0 kPa).
4. Close the manual fuel shutoff valve on the fuel panel.
5. Remove and save the two capscrews that secure the access cover to the fill panel, then remove the access cover. See Fig. 2.
6. Slowly open the bleed valve on the manifold to relieve remaining fuel pressure within the system. See Fig. 3.

IMPORTANT: Some pressure may remain in the fuel system between the solenoid valve and the engine. Use caution when loosening fittings, as a small amount of gas may leak out.

7. Disconnect the wiring harness from the solenoid valve.
8. Use a remote 12-volt power source to activate the solenoid valve to drain any compressed natural gas remaining in the fuel system between the solenoid valve and the engine.

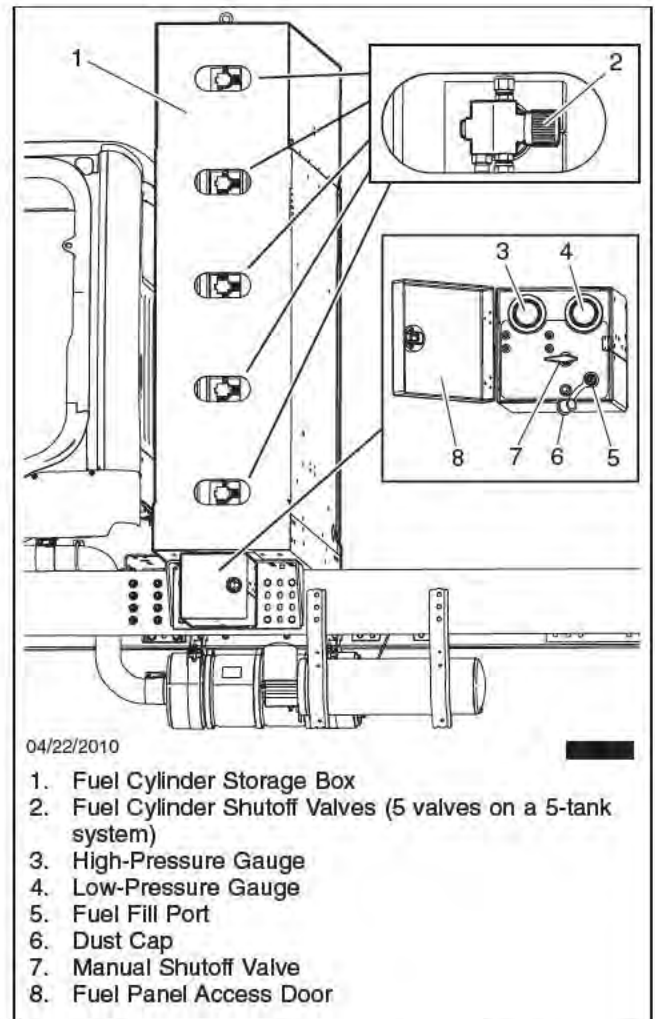


Fig. 1, CNG Fuel Cylinder Storage Box (5-cylinder system shown)

NOTICE

Disconnect the battery power and ground cables and any electronic control units (ECUs) installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, such as alternator diodes and ECUs. Freightliner vehicle components that typically use ECUs include electronic engine, electronic automatic transmission, and antilock braking system (ABS).

For any ECU with a battery power harness, disconnect its ground terminal from the chassis ground, and disconnect its power terminal from

Welding a CNG Vehicle

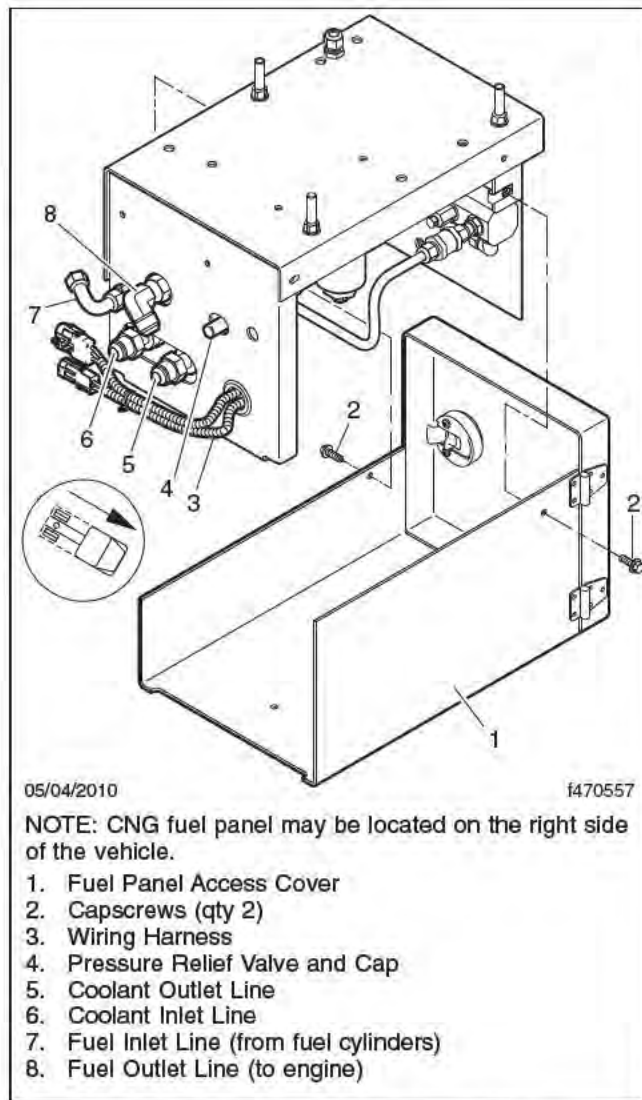


Fig. 2, CNG Fuel Panel Assembly

the battery positive post, or disconnect the main connection at the ECU.

9. Shut down all vehicle electrical systems and disconnect the battery.
10. Let the vehicle sit in a well-ventilated area for at least 10 minutes.

IMPORTANT: Do not weld in areas directly adjacent to CNG tanks. Avoid direct heat exposure on tanks.

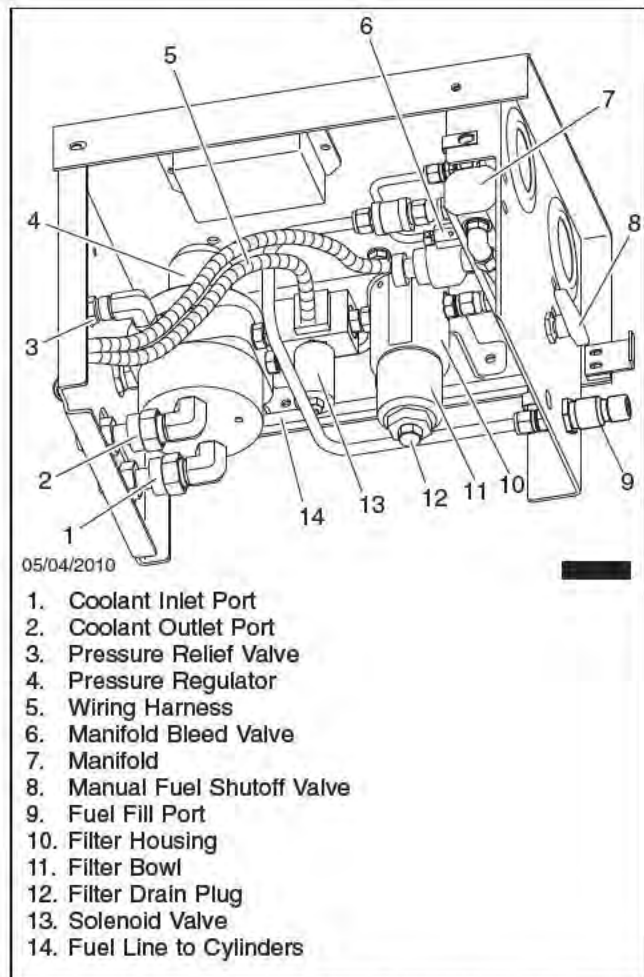


Fig. 3, CNG Fuel Panel Components

11. Cover the CNG tanks and fuel lines with a metal shield or welding blankets to prevent sparks or residue from contacting CNG equipment.
12. Complete all necessary welding, then remove the protective welding blankets or metal shield.
13. Start up the vehicle electrical system and connect the battery.
14. Connect the electrical harness to the solenoid valve.
15. Close the bleed valve on the manifold and open the manual fuel shutoff valve on the fuel panel.
16. Open the fuel cylinder shutoff valves.
17. Start the engine and check for gas leaks in the fuel system.

Using a methane detector, leak test all fuel system components. A bubble solution can be used to pinpoint the exact location of leaks.

Repair or replace any leaking components.

18. Using the two capscrews removed previously, install the access cover on the fill panel.

CNG System

See **Fig. 1** for a schematic of CNG fuel system components.

See **Fig. 2** for a flow chart to troubleshoot problems with an engine running lean.

See **Fig. 3** for a flow chart to troubleshoot a faulty dash-mounted fuel gauge reading.

See **Fig. 4** for a flow chart to troubleshoot a compressed natural gas leak in the fuel system.

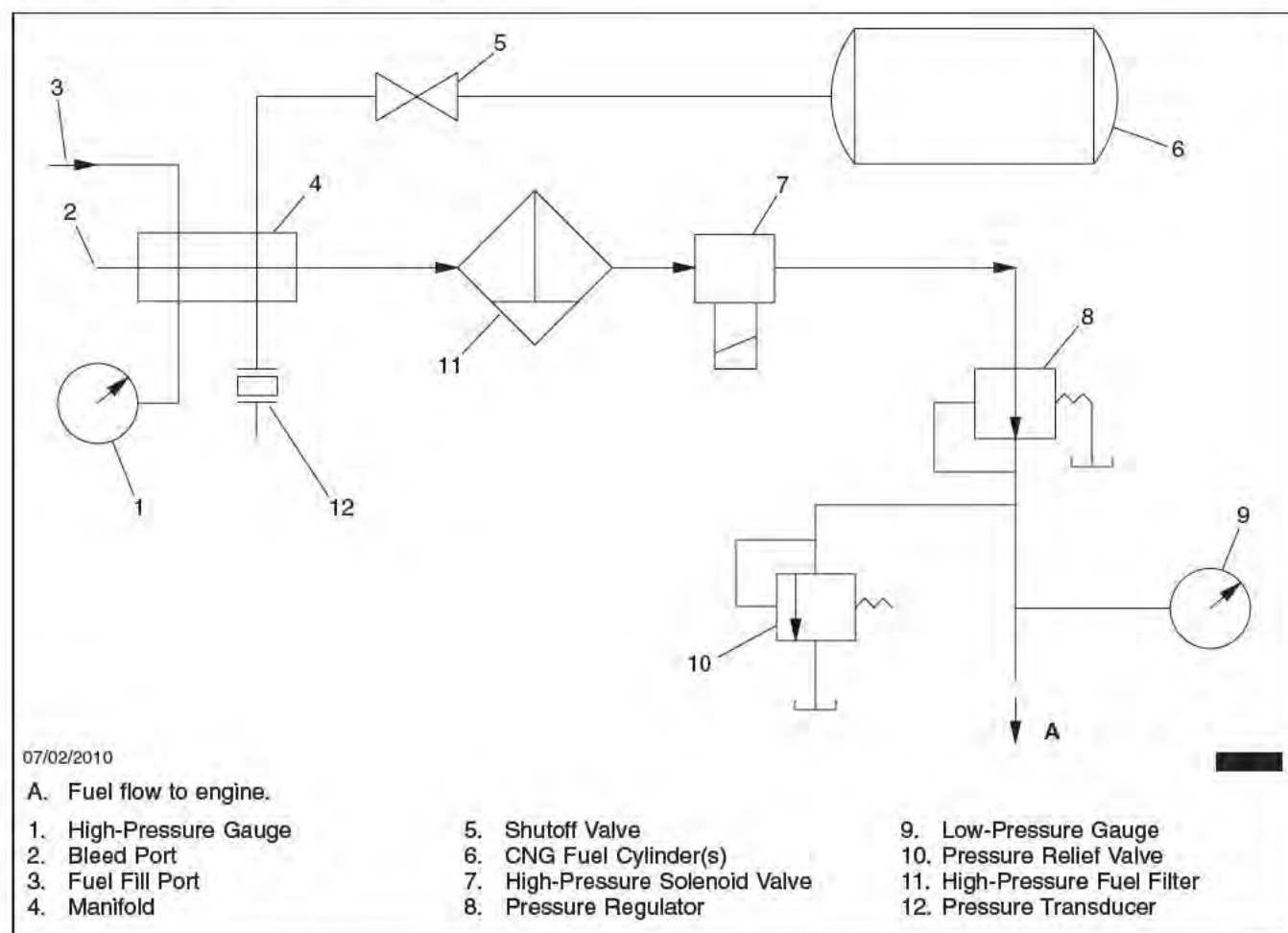


Fig. 1, CNG Fuel System Schematic (typical)

Troubleshooting

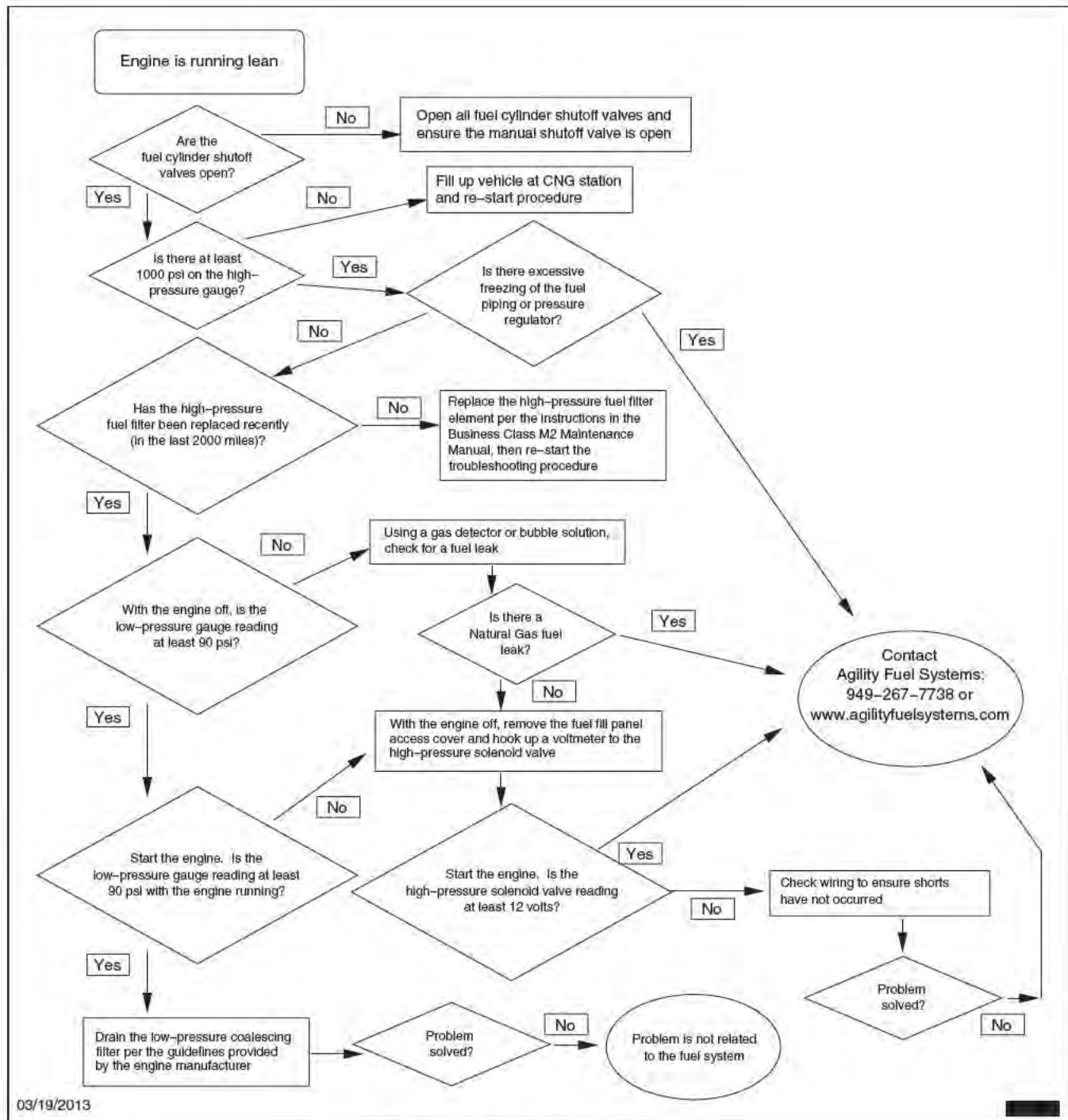


Fig. 2, Flow Chart: Engine Running Lean

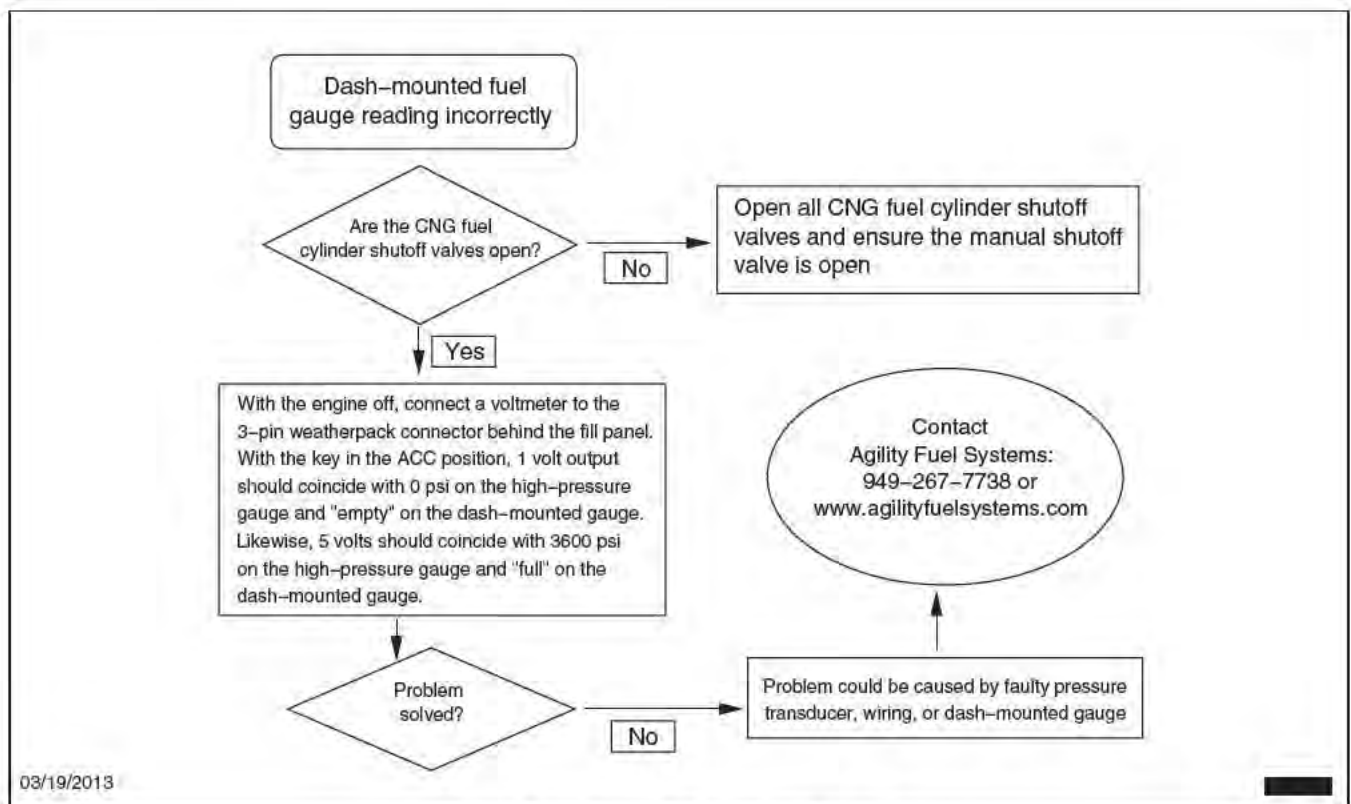


Fig. 3, Flow Chart: Faulty Dash Gauge

Troubleshooting

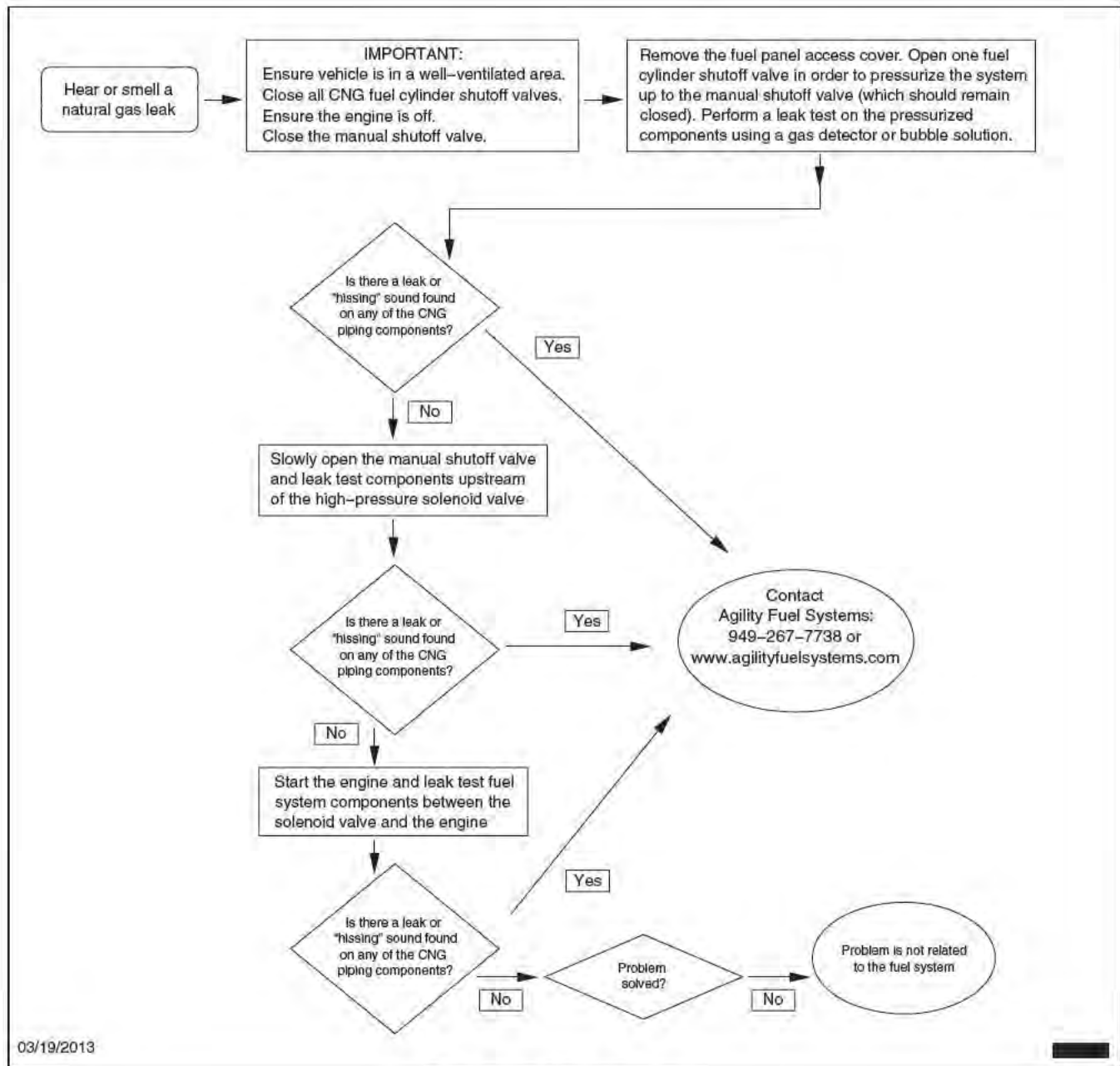


Fig. 4, Flow Chart: Gas Leak

Methane Detection System

WARNING

Compressed natural gas is highly flammable. Refer to the safety precautions listed in Subject 100 before servicing the vehicle. Failure to observe these precautions could lead to the ignition of the natural gas, which could cause severe bodily injury, death, or property damage.

The Business Class M2 is equipped with a two-zone natural gas detection system. One sensor is located in the cab overhead panel in the control panel, the other sensor is located on the frontwall in the engine compartment. The system is powered directly from the vehicle batteries and is active at all times, unless the batteries are disconnected. When the system has

power, and is operating normally with all sensors confirmed operational, and no leaks detected, the green "Power" LED, and the large green light are on. When the presence of gas is detected in any zone, an indicator LED will illuminate depending on the level of gas detected. If a problem with a sensor or wiring occurs, a "Fault" LED will illuminate for the zone that is affected. When a fault is present, no detection is operational in that zone. The following troubleshooting tables show all the different possible light combinations, what they indicate, the troubleshooting procedures, and the suggested remedy. For vehicle-specific wiring diagrams, refer to G06-89262 in EZWiring™.

IMPORTANT: Before performing any troubleshooting, allow the system 60 seconds to complete the initialization process.

Green "Power" Light On

		
Front Panel Indication	Troubleshoot	Remedy
The green "Power" LED on the main panel and the large green LED are on. The system has power and is operating normally. In this state the panel and all sensors are confirmed operational.	System is operating normally.	No repair needed.

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Compressed Natural Gas Fuel System

Troubleshooting

No Lights on Front Panel



03/06/2014

Front Panel Indication	Troubleshoot	Result	Remedy
No lights are illuminated on the panel. The panel has no power. No gas detection or warning is possible.	Are all of the connectors plugged in at the back of the panel?	Yes	Go to next the step.
		No	Plug in the connector. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
	Is there power (9-14 vdc) and ground at the panel?	Yes	Replace the panel.
		No	Go to the next step.
	Check the terminal on the back of the panel for loose or improperly installed pins. Were there any bad pins?	Yes	Repair and Go to next the step. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
		No	Go to the next step.
	Is the fuse blown or missing at the power-net distribution box (PNDB)?	Yes	Replace the fuse. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
		No	Go to next the step.
	Does the circuit have continuity or high resistance?	Yes	If it has continuity, and still has no power go to PNDB troubleshooting.
		No	If there is no continuity, or high resistance Go to next the step.
	Check connectors at the fire wall and PNDB.	Yes	Replace the damaged cable(s).
	Have any of the cables been pinched, cut, or damaged?	No	Contact the vendor.

Amber "Sensor Fault" Light On

			
Front Panel Indication	Troubleshoot	Result	Remedy
The amber "Sensor Fault" light indicates that there is a problem in the zone specified. In this case zone 1 and 2. When a fault light is on, detection is not possible in any zones where a fault is present.	Check the sensor connections at the back of the panel and at the sensors. Are the connectors loose or damaged?	Yes	Repair as needed. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
		No	Go to next the step.
	Check the pins in the connectors on the panel and in the sensors. Are the pins loose or damaged?	Yes	Repair as needed. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
		No	Go to next the step.
	If both "Sensor Fault" lights are on, skip this step and proceed to the next step. Swap the zone that is reporting a sensor fault by switching the connectors at the rear of the panel. Did the other light illuminate?	Yes	If the fault moves with the cable, proceed to the next step.
		No	If it stays, replace the panel. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
	Check for continuity in the harness. Is there high resistance in the sensor harness?	Yes	Replace the harness.
		No	Replace the sensor, unless it is both, then replace the panel.

Troubleshooting

Amber "Trace" Light Flashing



03/20/2014

Front Panel Indication	Troubleshoot	Result	Remedy
The flashing amber "Trace" light indicates that a trace amount of gas (greater than 20% and less than 50%) has been detected in the specified zone, in this case zone 2.	Using an approved NG testing method, check all fuel fittings and fuel lines for leaks.	Yes	Repair as needed. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
	Verify that pressure relief devices are not venting or leaking.		
	Is there a gas leak?	No	Go to next the step.
	Are any nuisance gases present? Nuisance gases can be caused by cleaners, paint, polish, lacquer, gasoline, strong adhesives, fiberglass repair, etc.	Yes	Clear the area of contaminants and check again. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
		No	Go to next the step.
	Check the connectors and pins on the panel and sensors. Are they damaged?	Yes	Repair as needed. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
		No	Go to next the step.
	Swap the zone that is reporting a sensor fault by switching the connectors at the rear of the panel. Did the other light illuminate?	Yes	If the fault moves with the cable, proceed to the next step.
		No	If it stays, replace the panel. If the problem is resolved, no further work is needed.
	check continuity and resistance in the sensor harness. Is the harness good?	Yes	Replace the sensor.
		No	Replace the harness.

⚠ WARNING

The following tests should only be performed after determining that it is safe to do so.

Remove all personnel from the area. Ventilate the area. Manually shut off the source of gas (propane/CNG/LNG, etc.).

Have the problem repaired by qualified personnel before further operation of the vehicle.

Do not perform "SIGNIFICANT" and "Trace" diagnosis, until the non-presence of gas is confirmed and the panel has had constant power for 60 seconds of calibration.

Red "SIGNIFICANT" Light, Amber "Trace" Lights, and Buzzer 1

 03/20/2014			
Front Panel Indication	Troubleshoot	Result	Remedy
The red "SIGNIFICANT" light and amber "Trace" lights and buzzer 1 indicate that a significant level of combustible gas (greater than 50% lower explosive limit (LEL)) has been detected in the applicable zone. In this case zone 2. Remove all personnel from the area. Ventilate the area. Manually shut off the source of gas (propane/CNG/LNG, etc.). Have the problem repaired by qualified personnel before further operation of the vehicle. Do not perform "SIGNIFICANT" and "Trace" diagnosis, until the non-presence of gas is confirmed and the panel has had constant power for 60 seconds of calibration.	Is the "Amerex Push to Test" button being held?	Yes	Let go.
		No	Go to next the step.
	Using an approved NG testing method, check all fuel fittings and fuel lines for leaks.	Yes	Repair as needed. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
	Verify that pressure relief devices are not venting or leaking.		
	Is there a gas leak?	No	Go to next the step.
	Are any nuisance gases present? Nuisance gases can be caused by cleaners, paint, polish, lacquer, gasoline, strong adhesives, fiberglass repair, etc.	Yes	Clear the area of contaminants and check again. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
		No	Go to next the step.
	Check the connectors and pins on the panel and sensors. Are they damaged?	Yes	Repair as needed. If the problem is resolved, no further work is needed.
		No	Go to next the step.
	Swap the zone that is reporting a sensor fault by switching the connectors at the rear of the panel. Did the other light illuminate?	Yes	If the fault moves with the cable, proceed to the next step.
		No	If it stays, replace the panel. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
	Check continuity and resistance in the sensor harness. Is the harness good?	Yes	Replace the sensor.
		No	Replace the harness.

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Compressed Natural Gas Fuel System

Troubleshooting

Red "SIGNIFICANT" Light, Amber "Trace" Lights, and Buzzers 1 and 2



03/20/2014

Front Panel Indication	Troubleshoot	Result	Remedy
The red "Significant" light and amber "Trace" lights along with buzzers 1 and 2 indicate that a significant level of combustible gas (greater than 50% LEL) has been detected in the applicable zone, in this case zone 2. Remove all personnel from the area. Ventilate the area. Manually shut off the source of gas (propane/CNG/LNG, etc.). Have the problem repaired by qualified personnel before further operation of the vehicle. The large red LED and buzzer 2 indicates the significant gas detection has been present for over 15 seconds and the relay has engaged. Do not perform "SIGNIFICANT" and "Trace" diagnosis, until the non-presence of gas is confirmed and the panel has had constant power for 60 seconds of calibration.	Is the "Amerex Push to Test" button being held and has it been held continuously for 15 seconds causing the relay to trip?	Yes	Release the button, and press the "Shutdown/Reset" button to reset the relay. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
		No	Go to next the step.
	Using an approved NG testing method, check all fuel fittings and fuel lines for leaks.	Yes	Repair as needed. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
	Verify that pressure relief devices are not venting or leaking.		
	Is there a gas leak?	No	Go to next the step.
	Are any nuisance gases present? Nuisance gases can be caused by cleaners, paint, polish, lacquer, gasoline, strong adhesives, fiberglass repair, etc.	Yes	Clear the area of contaminants and check again. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
		No	Go to next the step.
	Check the connectors and pins on the panel and sensors. Are they damaged?	Yes	Repair as needed. If the problem is resolved, no further work is needed.
		No	Go to next the step.
	Swap the zone that is reporting a sensor fault by switching the connectors at the rear of the panel. Did the other light illuminate?	Yes	If the fault moves with the cable proceed to the next step.
		No	If it stays, replace the panel. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
	Check continuity and resistance in the sensor harness. Is the harness good?	Yes	Replace the sensor.
		No	Replace the harness.

Red "Relay Engaged" LED, Large Red LED, and Buzzer 2

 03/20/2014			
Front Panel Indication	Troubleshoot	Result	Remedy
The red "Relay Engaged" LED and the large red LED along with buzzer 2 indicates that a significant level of gas (greater than 50%) was detected at some point. The significant gas level is no longer present, as the "SIGNIFICANT" LED and "Trace" LED are no longer illuminated. The panel relay has engaged and must be reset by pressing the "Shutdown/Reset" button. Do not troubleshoot the system until the reason for the significant alarm is understood.	Has the "Amerex Push to Test" button been pressed and held for 15 seconds causing the relay to trip?	Yes	Press the "Shutdown/Reset" button. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
		No	Go to next the step.
	Using an approved NG testing method, check all fuel fittings and fuel lines for leaks.	Yes	Repair as needed. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
	Verify that pressure relief devices are not venting or leaking.	No	Go to next the step.
	Is there a gas leak?	Yes	Clear the area of contaminants and check again. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
	Are any nuisance gases present? Nuisance gases can be caused by cleaners, paint, polish, lacquer, gasoline, strong adhesives, fiberglass repair, etc.	No	Go to next the step.
	Check the connectors and pins on the panel and sensors. Are they damaged?	Yes	Repair as needed. If the problem is resolved, no further work is needed.
		No	Go to next the step.
	Swap the zone that is reporting a sensor fault by switching the connectors at the rear of the panel. Did the other light illuminate?	Yes	If the fault moves with the cable, proceed to the next step.
		No	If it stays, replace the panel. If the problem is resolved, no further work is needed. If the problem still exists, go to the next step.
	Check continuity and resistance in the sensor harness. Is the harness good?	Yes	Replace the sensor.
		No	Replace the harness.