First Responder Guide: CNG and LNG Vehicle Fuel Systems

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Preface
This manual is designed as a supplemental guide for public safety first responders to compressed natural gas (CNG) or liquefied natural gas (LNG) vehicle fuel system incidents.

It does not cover response tactics for liquefied petroleum gas (LPG or propane) and does not cover response to vehicle fuel systems using Type 1 or Type 2 CNG cylinders.

This manual is not intended to replace any formal training on the proper response techniques, tactics or procedures for responding to alternative fuel vehicle (AFV) accidents or incidents.

NOTE
Always consult the National Fire Protection Association (NFPA) and your own training programs for the latest information and best practices for CNG and LNG emergency response.

Warning Messages Used in this Manual
NOTE
Best practices or hints to help an operation or procedure go smoothly

⚠️ CAUTION
Damage to equipment, fuel system or vehicle is possible if instructions are not followed

⚠️ DANGER or WARNING
Personal injury or death may occur if procedures are not followed

Contact Agility Fuel Systems Product Support Group to discuss any issues that are not addressed in this manual.
### Table 1 Revision History

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<th>Revision</th>
<th>Description</th>
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1. Compressed and Liquefied Natural Gas Facts
Natural gas (methane) is flammable; however, it only burns within a narrow range when mixed with air in a ratio of between 5 and 15 percent. Natural gas is odorless, colorless and tasteless. Natural gas is lighter than air so it rises and diffuses into the atmosphere when released.

Natural gas has unique hazards not found in gasoline and diesel fuel: Natural gas is in a gaseous state at normal temperatures and pressures. In order to be stored efficiently, it must be stored under high pressure (3600 psi) in a compressed natural gas (CNG) system or at an extremely low (cryogenic) temperature (-220°F to -212°F / -140°C to -136°C) in liquid form as liquefied natural gas (LNG).

2. Identifying CNG Vehicles
A vehicle equipped with a natural gas fuel system will have a decal on the rear of the vehicle identifying it as a compressed natural gas (CNG) or liquid natural gas (LNG) vehicle.

Figure 1 Left: CNG fueled vehicles are identified by a blue and white decal on the right rear of the vehicle. Right: A CNG decal may also be on the left front of the vehicle as shown.

Figure 2 Popular CNG fuel system configurations offered by Agility Fuel Systems.
3. General Information - CNG

1. There are four types of CNG cylinders:
   - Type 1: All metal construction
   - Type 2: Metal liner with hoop-wrap around cylinder
   - Type 3: Thin metal liner with continuous carbon-fiber over-wrap
   - Type 4: Plastic liner with continuous carbon-fiber over-wrap

   **NOTE:** Agility Fuel Systems use Type 3 and Type 4 cylinders

2. The CNG fuel cylinder or cylinders are housed in steel or aluminum structures secured to the vehicle body and frame. These structures are engineered to protect the cylinders in a collision.

3. The framework is covered with a composite or metal cover to protect the cylinders from UV exposure and enhances vehicle appearance and aerodynamics.

![Figure 3 Typical refuse roof mount CNG storage system. Aluminum covers protect the cylinders from overhead objects.](image)

![Figure 4 Five Type 3 or Type 4 CNG cylinders reside inside the housing. PRDs are located at each manual valve and centered along the length of the cylinder for a total of 10 PRD and vent locations.](image)
4. CNG cylinders may be mounted on the side rails of the vehicle, on the roof or behind the cab.
5. Fuel storage capacity can be increased by combining systems.
6. Each cylinder in a CNG system has a valve at one end to allow fuel to be isolated from the rest of the system. During operation, all cylinder valves should be open.
7. The cylinders are protected with one or more **thermally-activated** pressure relief devices (PRDs).
8. PRDs activate between 212°F to 220°F (100°C to 104°C). General PRD locations and venting directions are shown in Figures 5, 6 and 7.

⚠️ **CAUTION – WARNING**

A. CNG PRDs vent with full cylinder pressure, nominally 3600 psi or more.
B. Vehicle damage and position may modify venting gas direction.
C. Venting gas may ignite become a jet fire and can re-ignite several times.

*Figure 5 CNG PRD venting locations and direction, roof mount systems.*

*Figure 6 CNG PRD venting locations and direction, side mount systems.*
9. Remember, unlike a structure or utility fire, a natural gas vehicle will have a limited amount of fuel on board, so let the gas vent and watch for secondary exposures and hazards.

10. Refer to Figure 8. The fuel management module (FMM) is equipped with a 1/4-turn shut off valve which isolates the fuel storage system from the engine for maintenance or emergency situations. Although the location and arrangement of valves and gauges may vary, all FMMs are functionally the same.

Figure 7 CNG PRD venting locations and direction, front of body refuse system and transit bus.

Figure 8 CNG system fuel management module (FMM) gauges and controls.
4. Emergency Response - CNG

⚠️ CAUTION - WARNING
CNG pressures are nominally 3600 psi and can be as high as 4250 psi. Do not cut fuel supply tubing.

4.1 If the Vehicle Has Sustained Damage or a Gas Leak Is Discovered

1. Eliminate all sources of ignition such as fire, sparks, electronics, lights, or electrostatic charges. No smoking near the vehicle and do not light road flares.
2. Turn the ignition switch off (this will close the solenoid valve), set parking brake and turn off battery at main battery disconnect.
3. If it is safe to do so, close the manual shutoff valve, close the cylinder valves and check the fuel system near the damaged area for leaks using smell, sight and sound. CNG is odorized and can be detected by smell.
4. Keep people and traffic away from the area.
5. Open the doors of the vehicle to introduce fresh air.
6. If the vehicle is indoors, open windows and doors to allow ventilation and avoid turning on any lights or electronics which may create a spark. Pay particular attention to any sources of ignition overhead because natural gas will rise to the ceiling.
7. Beware that residual gas may still leak from the storage system even after the ignition switch is off and the manual shut off valves are closed.
8. Advise towing and wreckage storage operators the vehicle is fueled with CNG.
9. Have a qualified natural gas vehicle service technician make necessary repairs.

4.2 In Case of a Vehicle Fire - CNG

1. Establish a safety area of 80 to 100 feet.
2. **If the cylinders are not involved** in the fire, the fire on the vehicle can be extinguished with normal response tactics.

3. **If fire is impinging on the cylinders, or if the cylinders are on fire**, it is best to let the vehicle burn and watch for secondary hazards, such as other vehicles or structures.

⚠ **DANGER – WARNING**

A. **DO NOT** apply water to the cylinders because this will prevent the PRDs from activating and can result in a catastrophic cylinder failure (high pressure gas rupture).

B. After 5-10 minutes in a fire without PRD activation, the cylinder pressure can increase to 5000 psi or more.

C. **Burst pressure of an intact CNG cylinder is 8000 to 9000 psi.**

4. When a PRD activates, the result is often a jet fire – and may go out and re-ignite several times.
   a. A typical PRD on a CNG tank will require 2-5 minutes to activate. Total vent-down time is approximately 5 minutes from activation.
   b. The cylinder could survive in a fire for up to a total of 20-30 minutes.

5. Advise towing and wreckage storage operators the vehicle is fueled with CNG.

5. **General Information – LNG**

⚠ **CAUTION - WARNING**

A. **LNG is stored at cryogenic temperatures (-220°F to -212°F / -140°C to -136°C)** and is odorless. PPE should include gloves and face shields to prevent frostbite, a methane/flammable gas detector and self-contained breathing apparatus (SCBA).

B. **LNG fuel is a multi-phase mixture of liquid and gas at cryogenic temperatures:** The fuel pressure inside the LNG tank is **not** indicative of fuel level. A full tank could read zero pressure, and an empty tank could read 230 psi.

LNG cannot be odorized because of its very cold temperature, so methane detection systems are mandatory. One sensor is located in the engine compartment and one inside the cab.

1. LNG is extremely cold, and if spilled, will vaporize and dissipate into the air.
2. LNG fuel storage containers are highly insulated stainless steel tanks to keep the cryogenic fuel cold.
3. Systems are usually mounted on the vehicle sides, but can be located in similar locations as CNG systems, such as the vehicle roof.
4. Pressure relief devices for LNG are **not** thermally activated, so there is no danger of defeating or damaging the relief valves with water.

5. Manual valves are located on one end of the fuel tank, as shown in Figures 11 and 12.

6. An LNG fuel system may **normally** vent (via the primary relief valve) when the pressure inside the tank rises above 230 psi due to normal reaction (expansion) to ambient temperatures.
   a. The relief valve will automatically reset when the pressure decreases to 230 psi.
   b. LNG venting is considered normal, but excessive venting may indicate a problem.

7. Remember, unlike a structure or utility fire, a natural gas vehicle will have a limited amount of fuel on board, so let the gas vent and watch for secondary hazards, such as other vehicles or structures.

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**Figure 10** Left: LNG blue diamond decal location at the lower right rear of the cab on vehicles without bodies such as a roll-off refuse hauler. Right: LNG decal on the right end of the fuel tank.

**Figure 11** Left: LNG decal on the right rear of a transit bus. Right: The “valve end” of an LNG fuel tank.
Figure 12 LNG system valves. A pressure gauge is usually located on the side for easy viewing.

Figure 13 LNG vehicle, rear view. The LNG tank is on the lower left and the vent line runs from the tank and up along the rear of the cab, terminating above the cab. LNG vent tubes look like their CNG counterparts – but beware of the pressure difference and the reason a vehicle system is venting. See text for more details.
6. Emergency Response – LNG

⚠️ CAUTION - WARNING

A. LNG is stored at cryogenic temperatures (-220°F to -212°F / -140°C to -136°C) and is odorless. PPE should include gloves and face shields to prevent frostbite, a methane/flammable gas detector and self-contained breathing apparatus (SCBA).

B. LNG fuel is a multi-phase mixture of liquid and gas at cryogenic temperatures: The fuel pressure inside the LNG tank is **not** indicative of fuel level. A full tank could read zero pressure, and an empty tank could read 230 psi.

6.1 If the Vehicle Has Sustained Damage or a Gas Leak Is Discovered

Use caution when handling an LNG leak. LNG is stored at temperatures below -260°F and can cause first degree burns and frostbite if it comes in contact with skin. It is best to remove sources of ignition and allow leaking LNG fuel to vaporize and disperse into the atmosphere.

1. Establish a safety area of 80 to 100 feet.
2. Small LNG leaks can be seen as vapor escaping from the leak, usually at fittings.
3. Large liquid leaks may spill, but will vaporize and rise almost immediately. Be aware of the extreme cold and make sure PPE is in place for any exposed skin.
4. Turn the ignition switch off (this will close the solenoid valve), set parking brake and turn off battery at main battery disconnect.
   a. If it is safe to do so, turn off the main battery switch.
5. If it is safe to do so, close the red liquid valve and check the fuel system near the damaged area for frost, ice or condensation. This is an indicator of an LNG leak.
6. If the tank is damaged or there is frost on the tank, and the sound of fuel escaping can be heard, the gas will vaporize and rise into the air.
7. Be aware the pressure gauges may indicate zero, but some residual liquid may still be in the tank.
8. Keep people and traffic away from the area.
9. Open the doors of the vehicle to introduce fresh air.
10. If the vehicle is indoors, open windows and doors to allow ventilation and avoid turning on any lights or electronics which may create a spark. Pay particular attention to any sources of ignition overhead because natural gas will rise to the ceiling.
11. Beware that residual gas may still leak from the storage system even after the ignition switch is off and the manual valves are closed.
12. Advise towing and wreckage storage operators the vehicle is fueled with LNG.
13. Have a qualified natural gas vehicle service technician make necessary repairs.
6.2 In Case of a Vehicle Fire - LNG

1. Establish a safety area of 80 to 100 feet.

2. **If the LNG tanks are not involved** in the fire, the fire on the vehicle can be extinguished with normal response tactics.

3. **If fire is impinging on the LNG tanks**, it is best to let the vehicle burn and watch for and protect secondary hazards and exposures, such as other vehicles and structures.

4. Water can be used to extinguish the fire because LNG tanks are well insulated.
   a. LNG tanks are well insulated so temperature and pressure rise should be small.
   b. The LNG pressure relief valve will open and the gas will vent.
   c. LNG pressure relief valves are self-resetting (resets when pressure is below about 230 psi).

5. If it is safe to do so, turn off the main battery switch.

6. Advise towing and wreckage storage operators the vehicle is fueled with LNG.

7. **References and Additional Information**

The following publications and resources will help increase your understanding of CNG and LNG fuel systems.

NFPA offers a free Alternative Fuel Vehicles Training Program to US Emergency Responders:
http://nfpatoday.blog.nfpa.org/

Go to the Agility Fuel Systems website – Product Support Group page to download or view these publications:
http://www.agilityfuelsystems.com/product-support-contact-info.html

- CNG and LNG Fuel System Videos