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First Responder Guide: CNG and LNG Vehicle Fuel Systems

ENP-084 Rev. D

June 29, 2020

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II. Preface

This manual is 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) or CNG 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.

IMPORTANT:

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.

III. Warning Statements Used in this Manual



Will cause death or severe injuries if procedures are not followed.



Could cause death or severe injuries if procedures are not followed.



Could cause minor or moderate injuries if procedures are not followed.



Practices not related to physical injury. Includes procedures to prevent vehicle damage as well as hints to help an operation or procedure go smoothly.

IV. Obtaining Product Support, Service or Parts

Fuel system product support can be obtained by calling the Agility® Customer Care Hotline:

+1 949 267 7745

+1 855 500 2445 toll free

Customer Care: support@agilityfs.com

Parts: parts@agilityfs.com

Visit the Agility® website for more information, including CNG and LNG fuel system videos:

www.agilityfuelsolutions.com

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Revision	Description	Author	Approved By	Date
--	Initial Release	A. Durrant		
A	Changed format, no information changes	W. Yoshida	Y. Coy	07/09/2013
B	Complete re-write	W. Yoshida	C. Forsberg	08/24/2015
C	Updated company address and logos, added ANSI Z535 warning icons, updated NFPA training URL, re-formatted manual	W. Yoshida	M. Meyer	07/26/2017
D	UPDATED: Section III Signal word definitions; REVISED: Section 8 and Section 12. ADDED: Metric values; AMENDED: Section 2 to include LNG vehicle identification. CORRECTED: LNG storage temperature	C.Grasso	CCG and Engineering Team	06/29/2020

1. Compressed Natural Gas 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: In order to be stored efficiently, natural gas must be either 1) maintained under high pressure [3600 psi (25MPa)] in a compressed natural gas (CNG) system, or 2) kept at an extremely low (cryogenic) temperature of -259°F (-161°C) or cooler in liquid form as liquefied natural gas (LNG).

2. Identifying CNG and LNG Vehicles

The United States Department of Transportation (USDOT) requires vehicles equipped with natural gas fuel systems to have a diamond shaped decal affixed the rear of the vehicle identifying the vehicle as a powered by CNG or LNG. Additional CNG and LNG decals may be affixed to the front and sides of the vehicle. *Figures 1a and 1b*



Figure 1a. 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 affixed to the left front of the vehicle.

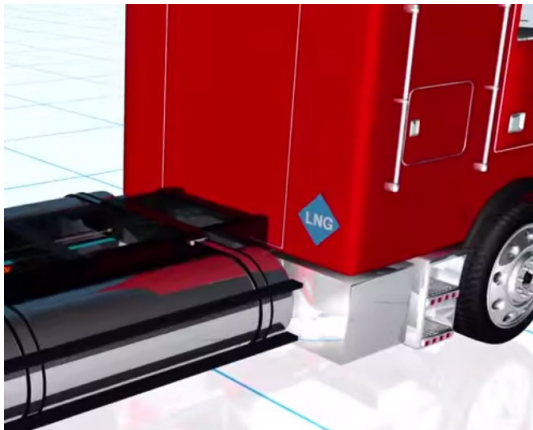


Figure 1b. Top: LNG fueled vehicles are identified by a blue and white diamond decal. Left: LNG blue diamond decal location on lower right rear of cab on vehicles without bodies such as roll-off refuse haulers. Right: LNG decal on the side mount fuel tank. Bottom: LNG decal on the right rear of a transit bus.

Additionally, CNG vehicles must display the appropriate diamond decal next to the USDOT number on the left and right sides of the vehicle. *Figure 2*

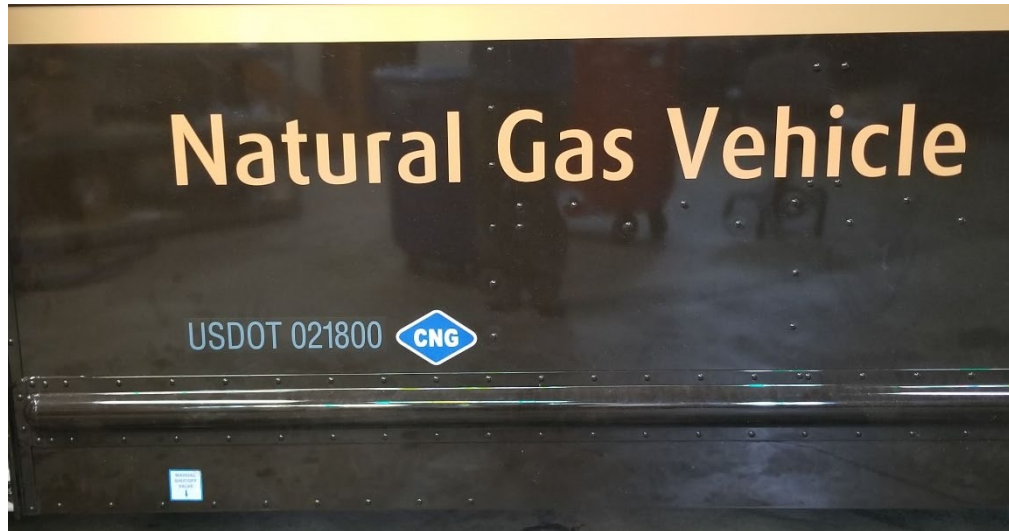


Figure 2. CNG diamond decal affixed adjacent to vehicle USDOT number. NOTE: Driver side shown; passenger side similar.

Agility[®] produces fuel systems for both CNG and LNG fuel vehicles for a variety of vocations and in several configurations. *Figures 3a, 3b, and 3c*



Figure 3a. Popular heavy duty Agility[®] CNG fuel system configurations.



Figure 3b. Medium duty Agility[®] CNG side mount fuel system. NOTE: CNG fuel cylinders (not visible) bolt to chassis frame rails and are protected by vehicle body and shields.



Figure 3c. Two LNG fuel system configurations offered by Agility[®].

3. CNG Vehicle Cylinders and Fuel Systems

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

Of the four cylinder types, Type 3 and Type 4 cylinders are most prevalent in commercial vehicles. Agility[®] uses 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.

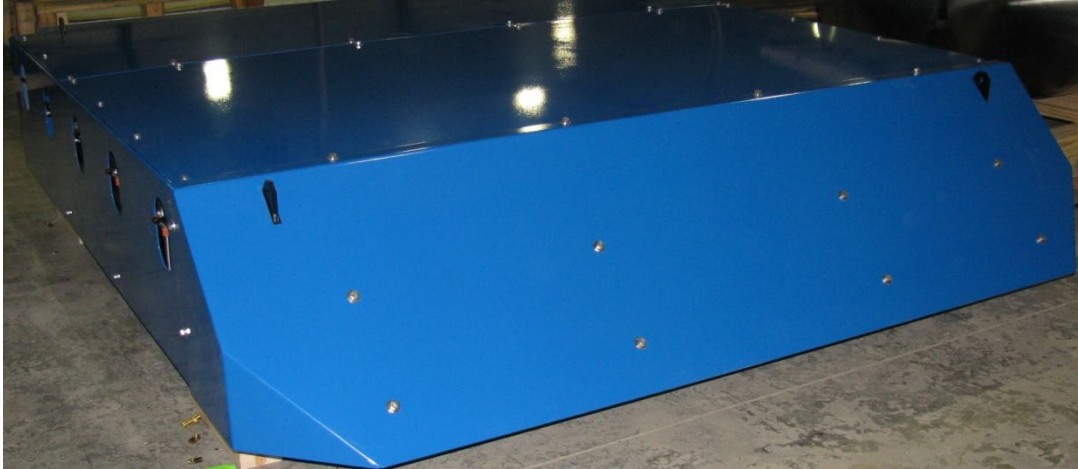


Figure 4. Typical refuse roof mount CNG storage system. Aluminum covers protect the cylinders from overhead objects.



Figure 5. Type 4 CNG cylinders in a housing with the cover partially removed. PRDs are located at each valve and at various locations along the length of the cylinder.

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 normal operation, all cylinder valves should be open.

4. CNG Pressure Relief Devices (PRDs)

⚠️ WARNING ⚠️ CAUTION

- A. CNG PRDs vent system pressure. Systems are designed for a nominal working pressure of 3600 psi (25MPa).
 - B. Vehicle damage and position may modify venting gas direction.
 - C. Venting gas may ignite, become a jet fire, extinguish itself and re-ignite several times.
1. CNG fuel cylinders are protected with one or more **thermally-activated** pressure relief devices (PRDs).
 2. CNG PRDs activate (vents gas) between 212°F to 220°F (100°C to 104°C).
 3. Typical CNG PRD vent tube locations and venting directions are as follows:
 - a) For side mount and behind the cab systems, PRD venting is routed up to a vent tube behind the cab or at the rear of the vehicle body. *Figures 6a and 6b*
 - b) Some older CNG PRD vent systems vent downward. *Figure 6c*
 - c) For roof mount refuse vehicle systems, a vent tube at the rear vents upward and to the rear. *Figure 7*
 - d) On front of body refuse vehicle systems, a vent tube at the rear vents upward and forward. *Figure 8*
 - e) On roof mount bus systems, a vent tube located at the rear of the roof vents to the rear. *Figure 9*



Figure 6a. CNG PRD venting location and direction (arrows), side mount and behind the cab systems.



Figure 6b. CNG PRD vent tube outlet location and vent directions (arrows), medium duty side mount system.



Figure 6c. CNG PRD venting location and direction (arrow), older side mount systems.



Figure 7. CNG PRD venting location and direction (arrow), refuse roof mount systems.



Figure 8. CNG PRD venting location and direction (arrow), front of body refuse system.



Figure 9. CNG PRD venting locations and directions (arrow), transit bus.

⚠️ WARNING

4. Remember, unlike a structure or utility fire, a natural gas vehicle has a limited amount of fuel on board. Allow gas to vent and watch for secondary exposures and hazards.

5. CNG Fuel Management Module (FMM)

The fuel management module (FMM) is equipped with a 1/4-turn manual shut off valve which isolates the fuel storage system from the engine for maintenance or emergency situations. The FMM may be separate from the cylinders or integrated into the cylinder housing. Although the location and arrangement of valves and gauges may vary, all FMMs are functionally the same. *Figures 10 and 11*

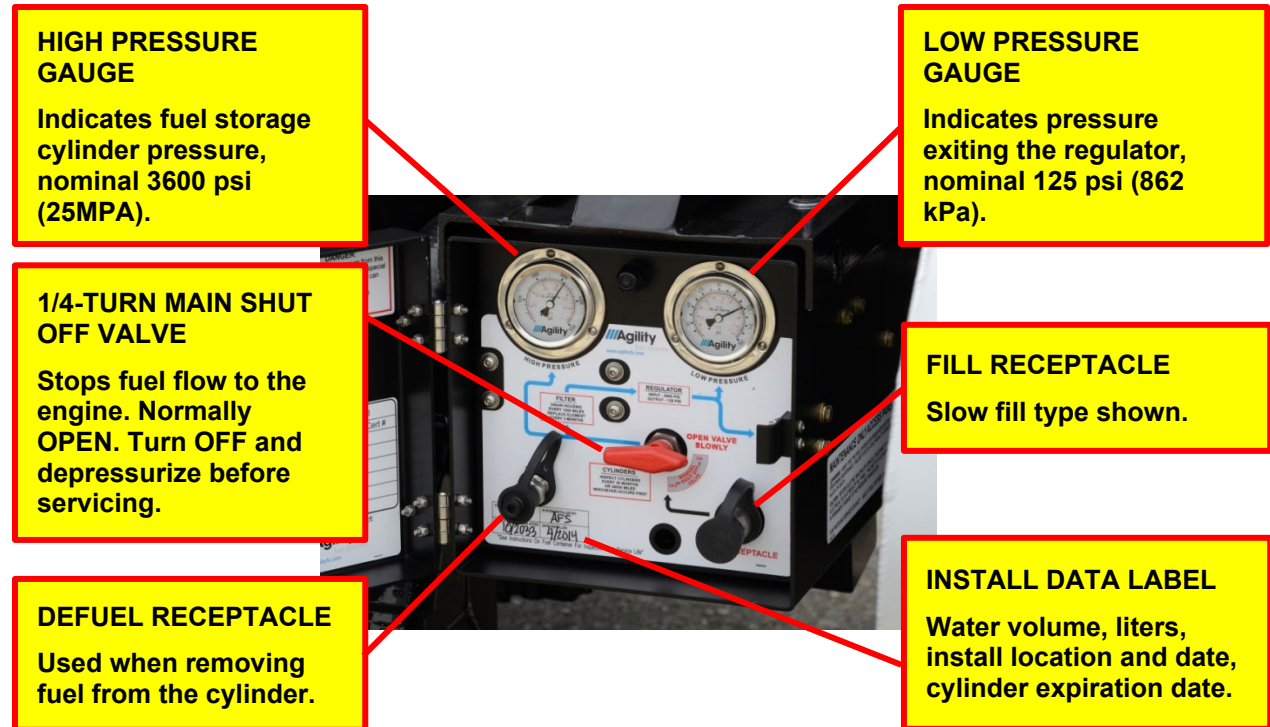


Figure 10. CNG system fuel management module (FMM) gauges and controls.

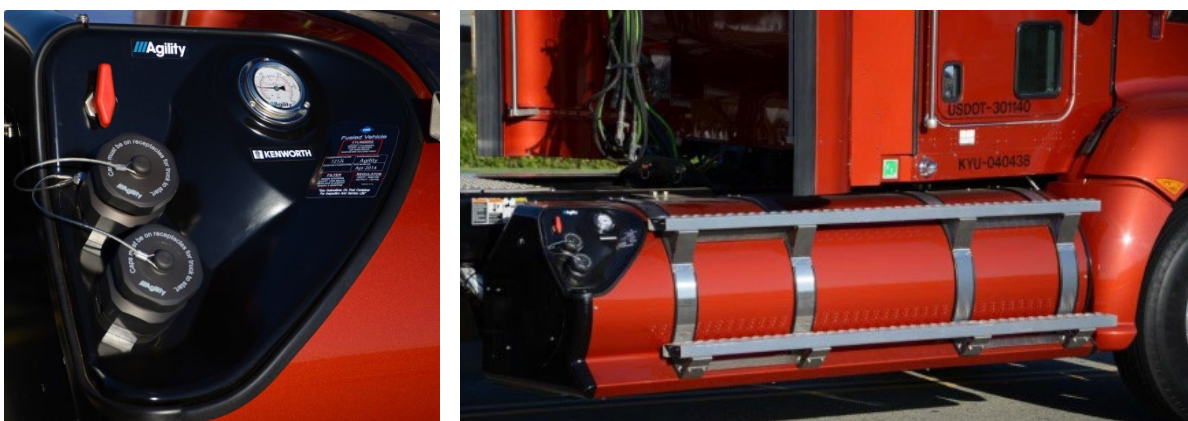


Figure 11. Integrated FMM (left) mounted on a CNG side mount system (right).

6. CNG Vehicle Emergency Response

WARNING **CAUTION**

CNG pressures are nominally 3600 psi (25MPa) or more when full. Do not cut fuel supply tubing.

6.1. If a CNG Vehicle is Damaged or a Gas Leak Is Discovered

1. Eliminate all sources of ignition such as fire, sparks, electronics, lights, or electrostatic charges. Do not smoke 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 1/4-turn manual shutoff valve, close individual 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. Use a combustible gas meter to monitor for potential fuel leaks.
5. Keep people and traffic away from the area.
6. Open vehicle doors to introduce fresh air to prevent natural gas accumulation.
7. If the vehicle is indoors, open building windows and doors to allow ventilation and avoid turning on any lights or electronics which may create a spark. Pay attention to overhead ignition sources because natural gas will rise to the ceiling.
8. Beware that residual gas may still leak from the storage system even after the ignition switch is off and manual shut off valves are closed.
9. Advise towing and wreckage storage operators the vehicle is fueled with CNG.
10. Have a qualified natural gas vehicle service technician make necessary repairs or defuel the vehicle.

6.2. In Case of a CNG Vehicle Fire

DANGER **WARNING**

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

WARNING

1. Always assume a CNG cylinder is under pressure.
2. Establish a minimum safe perimeter of 80-ft to 100-ft (25m to 31m) around the vehicle per NFPA recommendation.
3. **If the CNG cylinders are not involved in the fire**, the fire on the vehicle may be extinguished with normal response tactics. For example, small blazes such as brake fires and electrical fires.

WARNING

Fire exposure may not always be apparent.

WARNING

When fighting a CNG fire, keep in mind CNG properties and storage methods. Monitor the situation closely as changing conditions may require a change in tactics.

WARNING

4. **If fire is impinging on the CNG cylinders, if cylinders are on fire, or if the fire is fueled by an active leak, DO NOT APPROACH THE VEHICLE.** Allow the fire to burn while watching for secondary hazards, such as other vehicles or structures, and protecting exposures.

WARNING

5. *If it is safe to approach the vehicle, always approach at a 45 degree angle.*

WARNING

6. *If it is safe to do so, immediately chock vehicle wheels to prevent accidental movement.*
7. When a PRD activates, the result is often a jet fire which may go out and re-ignite several times.
8. Advise towing and wreckage storage operators the vehicle is fueled with CNG.

7. LNG General Information

WARNING **CAUTION**

- A. LNG is stored at cryogenic temperatures [-259°F (-161°C) or cooler] 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 (1.6MPa).

LNG cannot be odorized because of its very cold temperature; therefore, methane detection systems are mandatory. One sensor is located in the engine compartment and one is located 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. *Figure 12*



Figure 12. Stainless steel LNG fuel tank with LNG blue diamond decal.
NOTE: Passenger side shown; driver side similar.

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 each fuel tank. *Figures 13 and 14*



Figure 13: LNG fuel tank valve end with protective shield installed.
NOTE: Driver side shown; passenger side similar.

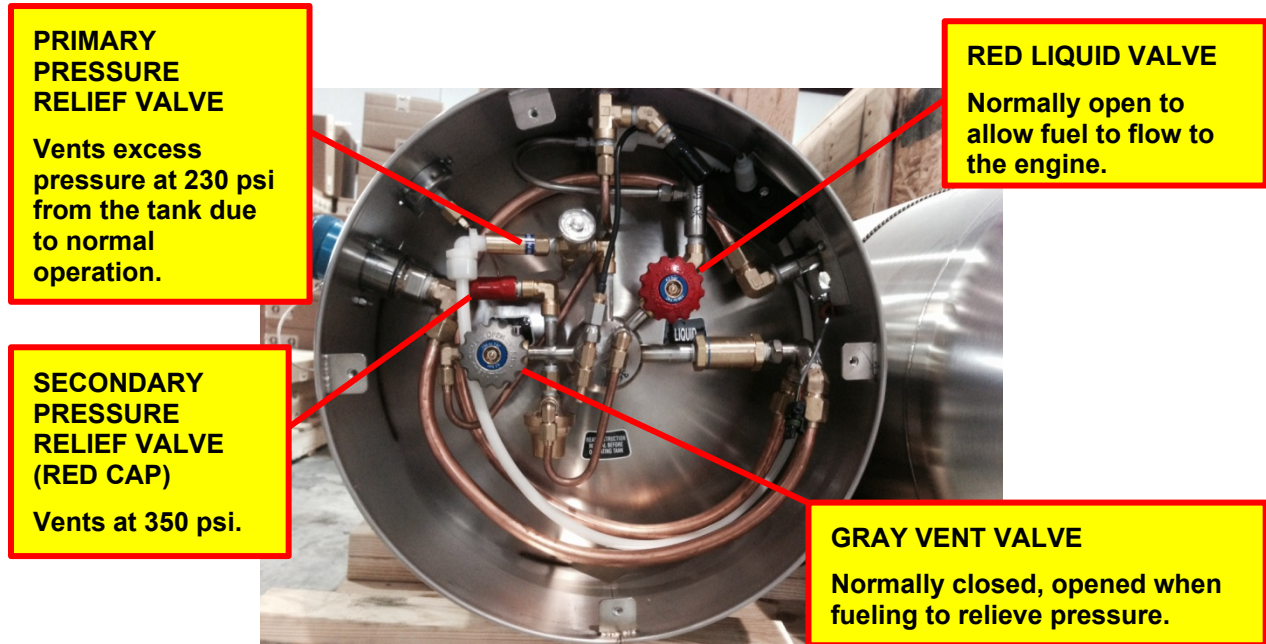


Figure 14. LNG system valve locations and functions.

6. Pressure gauges are mounted on or near each LNG tank. *Figure 15*

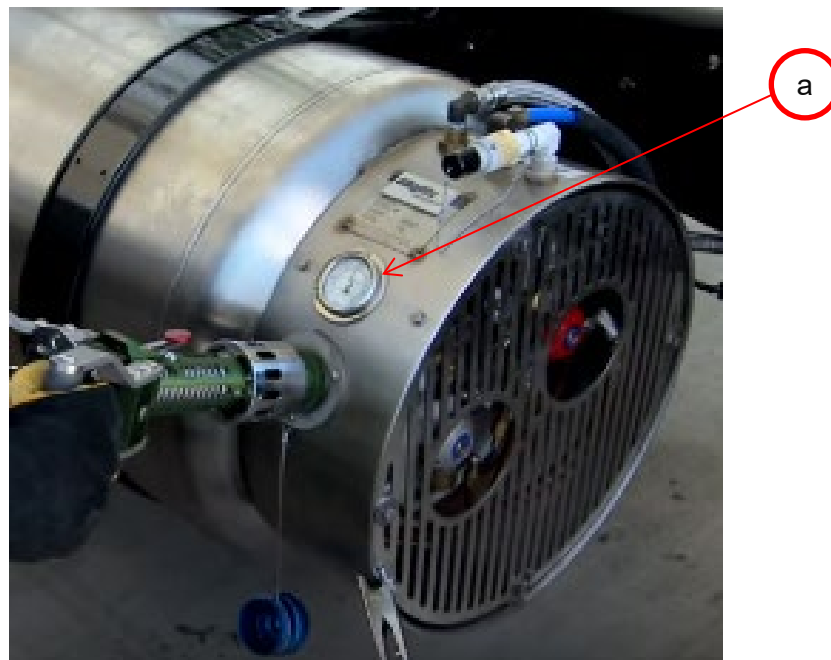


Figure 15 Pressure gauge (a) is typically located on each LNG tank for easy viewing.

7. An LNG fuel system may **normally** vent (via the primary relief valve) when the pressure inside the tank rises above 230 psi (1.6MPa) due to normal reaction (expansion) to ambient temperatures. *Figure 14*

a. The relief valve will automatically reset when the pressure decreases to 230 psi (1.6MPa). *Figure 14*

- b. LNG venting is considered normal, but excessive venting may indicate a problem.
Figure 16

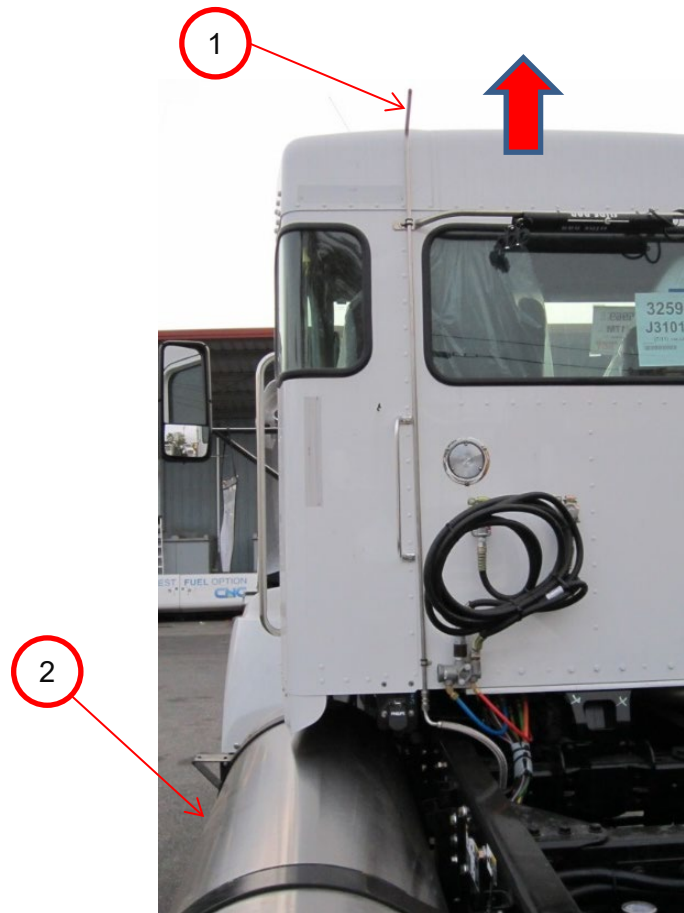


Figure 16. LNG vent line (1) runs from LNG fuel tank (2) along the rear of the cab to above the vehicle roof to vent gaseous fuel (arrow). LNG vent tubes resemble CNG PRD vent tubes, but LNG vent tubes are not capped. Also, be aware that LNG vehicles may vent in normal operation. Refer to text for more details.

8. Remember, unlike a structure or utility fire, an LNG vehicle has a limited amount of fuel on board. Allow gas to vent and watch for secondary hazards, such as other vehicles or structures. *Figure 16*

8. LNG Vehicle Emergency Response

⚠️ WARNING ⚠️ CAUTION

- A. LNG is stored at cryogenic temperatures [-259°F (-161°C) or cooler] 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: 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 (1.6MPa).

8.1. If an LNG Vehicle is Damaged or a Gas Leak is Found

Use caution when handling an LNG leak. LNG is stored at temperatures below -260°F (-162°C) and can cause first degree burns and frostbite if it contacts skin. It is best to remove sources of ignition and allow leaking LNG fuel to vaporize and disperse into the atmosphere.

WARNING

1. Always assume an LNG tank is under pressure.
2. Establish a minimum safe perimeter of 80-ft to 100-ft (25m to 31m) around the vehicle per NFPA recommendation.
3. Use a combustible gas meter to monitor for potential fuel leaks.
4. Small LNG leaks may be observed as vapor escaping from the leak, usually at fittings.
5. 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.
6. Turn the ignition switch off (this closes the solenoid valve).
 - a. Set parking brake.
 - b. If it is safe to do so, turn off the main battery switch.
7. *If it is safe to do so*, close the red liquid valve (Figure 13) and check the fuel system near the damaged area for frost, ice, or condensation which is an indicator of an LNG leak.
8. 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.

WARNING

9. Be aware the pressure gauges may indicate zero, but some residual liquid may remain in the tank.
10. Keep people and traffic away from the area.
11. Open vehicle doors to introduce fresh air and prevent gas accumulation.
12. If the vehicle is indoors, open building 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.

WARNING

13. Beware that residual gas may still leak from the storage system even after the ignition switch is off and all manual valves are closed.
14. Advise towing and wreckage storage operators the vehicle is fueled with LNG.
15. Have a qualified natural gas vehicle service technician make necessary repairs.

8.2. In Case of an LNG Vehicle Fire

1. Establish a minimum safe perimeter of 80-ft to 100-ft (25m to 31m) around the vehicle.
2. **If the LNG tanks are not involved in the fire**, the fire on the vehicle can be extinguished with normal response tactics.

WARNING

Fire exposure may not always be apparent.

WARNING

- a. Apply copious amounts of water to the LNG tanks.
 - b. **If LNG tanks are not kept cool with water, there is potential for a boiling liquid expansion vapor explosion (BLEVE). Therefore, if a sufficient water supply is not available, suspend water application and evacuate to a safe distance.**
3. **If fire is impinging on the LNG tanks, or if the fire is fueled by an active leak**, allow the fire to burn while watching for secondary hazards, such as other vehicles or structures, and protecting exposures.

WARNING

4. *If it is safe to approach the vehicle*, always approach at a 45 degree angle.

WARNING

5. *If it is safe to do so*, immediately chock vehicle wheels to prevent accidental movement.
6. 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 causing CNG to vent.
 - c. LNG pressure relief valves are self-resetting (resets when pressure is below about 230 psi (1.6MPa).
7. *If it is safe to do so*, turn off the main battery switch.
8. Advise towing and wreckage storage operators the vehicle is fueled with LNG.

9. References and Additional Information

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

National Fire Protection Association. *Emergency Field Guide: Hybrid, Electric, Fuel Cell, and Gaseous Fuel Vehicles, 2018*. (Free PDF download).

NFPA also offers a free Alternative Fuel Vehicles Safety Training Program to U.S. emergency responders:

<http://www.nfpa.org/training-and-events/by-topic/alternative-fuel-vehicle-safety-training>

LNG training video:

Pipeline and Hazardous Materials Safety Administration. "Liquified Natural Gas Safety and Emergency Response." https://www.youtube.com/watch?v=vnoU_k8CIUQ
Accessed June, 23, 2020.

Go to the Agility Fuel Solutions website – Product Support Group page to download or view these publications:

<https://agilityfuelsolutions.com/support-documents/>

- Agility Fuel Solutions, "Truck and Tractor CNG Fuel System Operation, Maintenance & Inspection Manual," ENP-516
- Agility Fuel Solutions, "CNG System Users' Manual," ENP-314
- Agility Fuel Solutions, "Safely Working on CNG Fuel Systems," ENP-391
- Agility Fuel Solutions, "Dual Tank LNG System Operation Manual," ENP-064
- Agility Fuel Solutions, "LNG System Users' Manual," ENP-334
- CNG and LNG fuel system videos