CNG Vehicles: Fundamentals for Firefighters

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NGVi Natural Gas Vehicle Institute

Introduction

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Hexagon Agility®, a business of Hexagon Composites, is a leading global provider of clean fuel solutions for commercial vehicles and gas transportation. Its product offerings include natural gas storage and delivery systems, Type 4 composite natural gas cylinders, propane, and natural gas fuel systems. These products transport clean gaseous fuels and enable vehicles to reduce emissions while saving operating costs. Learn more at www.hexagonagility.com and follow us on social media.


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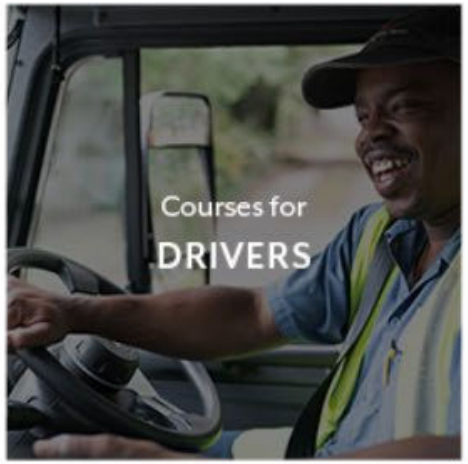
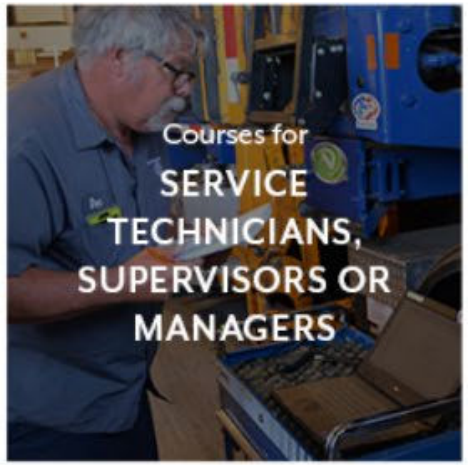
NGVi is the leading training provider in North America for the natural gas vehicle industry.
We are the new standard of NGV training for organizations that truly care about safety.

NGVi Delivers Training for Every Audience





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Today's Topics

- **Module 1:** How Natural Gas Differs from Gasoline/Diesel and Why It's Important
- **Module 2:** CNG Vehicle Essentials
  - How to Identify
  - Critical Components
    - Cylinders/Valves/PRDs/Tubing
- **Module 3:** Proper CNG Vehicle Fire Response

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How Many Natural Gas Vehicles Are Currently on the Road?

U.S.	**~175,000**
Worldwide	23,000,000+

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Just One of the Benefits of Natural Gas as a Transportation Fuel

- Vehicles powered by conventional natural gas are 90% cleaner overall than diesel vehicles
  - Lower in total hydrocarbon emissions
  - Up to 85% less CO
  - Up to 95% less NO_x
  - Up to 25% less CO_2 (greenhouse gas emissions)
  - Up to 99% less carcinogenic particulate emissions

- Vehicles powered by Renewable Natural Gas (RNG) have a carbon-negative footprint
  - They remove more CO_2 than they emit

Why This Training is Essential

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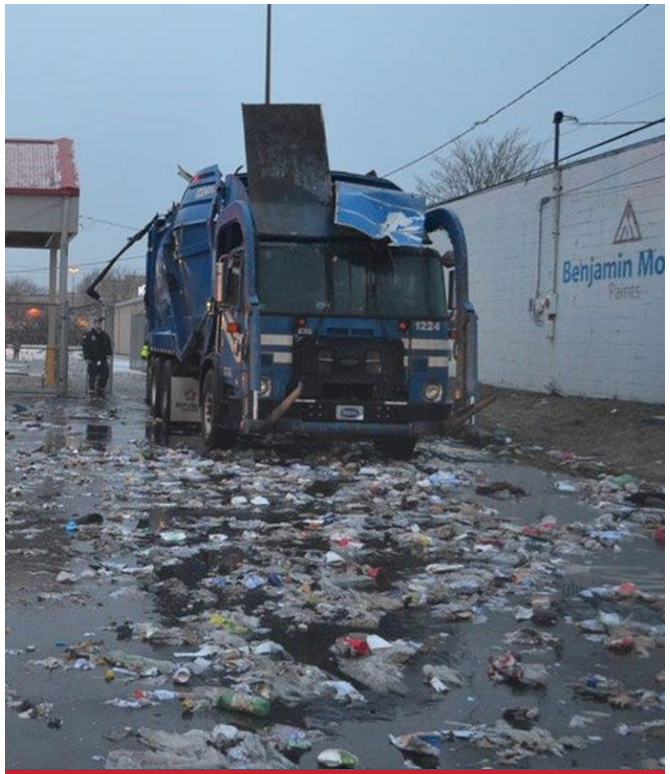
When a CNG vehicle fire occurs, and fire fighters are untrained…



Vehicle is destroyed

CNG cylinders rupture

Cylinders “launch”

Module 1: Properties and Characteristics of Natural Gas

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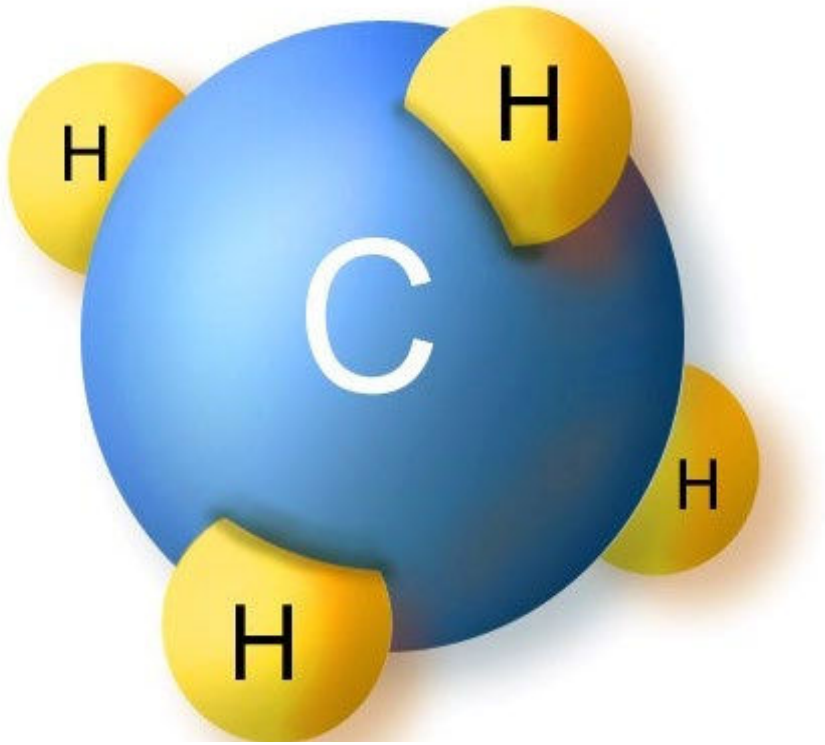
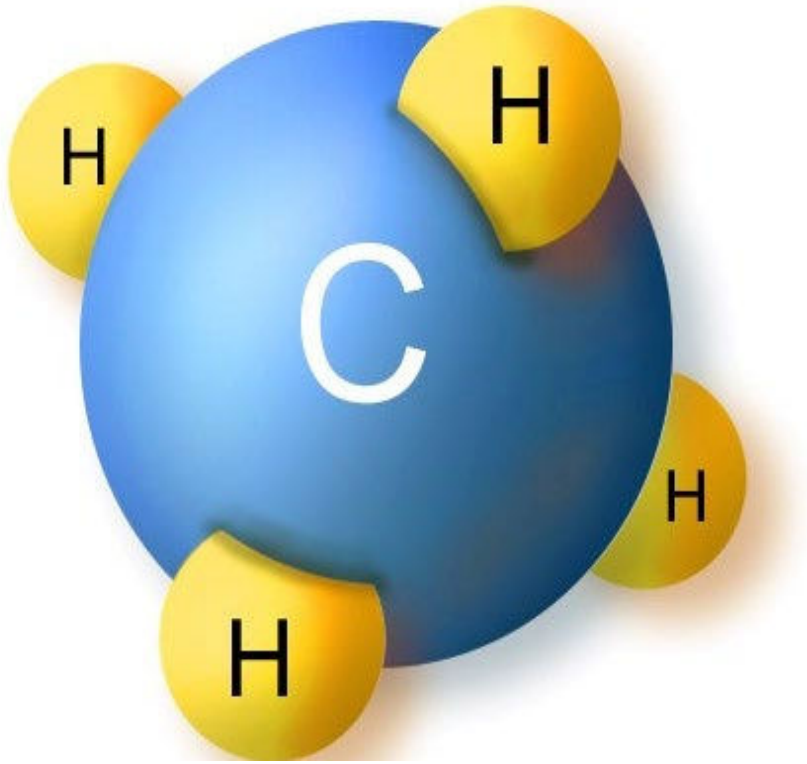
Chemical Properties of Natural Gas

- 90-96% methane
- Other components include:
  - Ethane
  - Propane
  - Butane



Physical Properties of Natural Gas

- Gaseous state
- Specific gravity .55 - .65 (air =1)
- Colorless and tasteless
- Odorless but odorants are added for human detection
- Non-toxic
- Non-corrosive



How CNG Compares to Gasoline and Diesel Ignition and Flammability

Property	Gasoline	Diesel Fuel	CNG
Ignition Temperature	580˚F	410˚F	900-1,080˚F
Flammability Range	1.4-7.7%	.6-7.5%	5-15%

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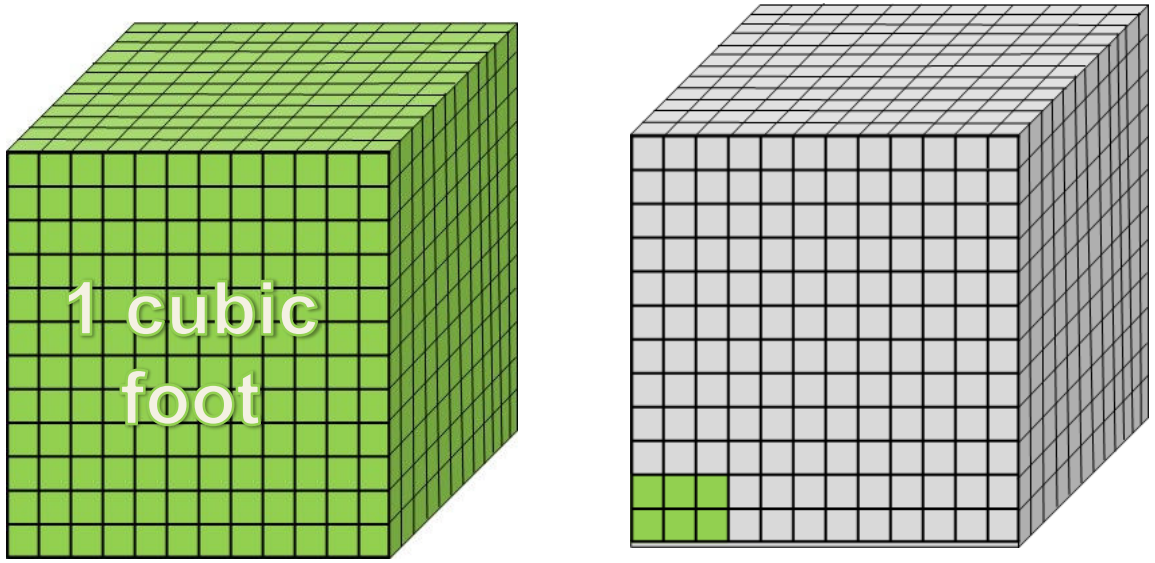
Natural Gas is Compressed to Increase its Energy Density



- 1 cubic foot = 5.6 cubic inches @ 3600 psi
- At 3,600 psi, nearly 300x volume

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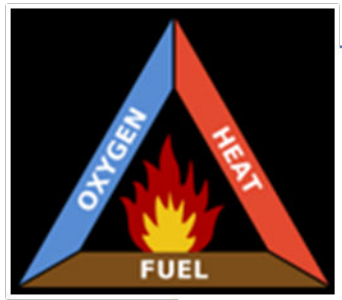
How CNG Is Stored Onboard Vehicles

Compressed Gas

High pressure – nominal 3,600 psi @ 70° F

Hazards of Natural Gas

Pressure



Fire

Asphyxiation

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NGV Safety Features to Address Pressure

	Operating Pressure (Service Pressure)	Rated Pressure (MAWP)	Required Safety Factor	Minimum Burst Pressure
Components	3,600 psi	5,000 psi	4:1	20,000 psi
Cylinders	3,600 psi	3,600 psi @ 70°F	2.25:1	8,100 psi

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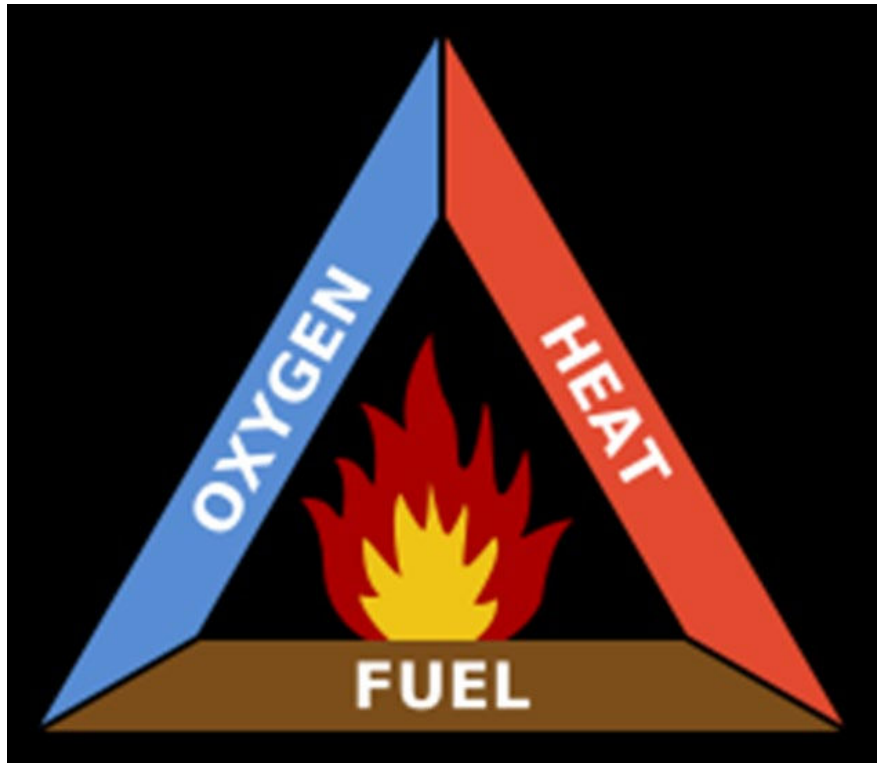
Natural Gas Safety Features to Address Fire

- No oxygen in the fuel system (<0.5%)
- Higher ignition temperature
- Higher flammability range
- Lighter than air



Natural Gas Safety Features to Address Asphyxiation

- Simple asphyxiate
- Odorant enhances detection

Module 2: CNG Vehicle Essentials for Fire Fighters

Labeling: How to Identify CNG Vehicles

- USDOT requires diamond-shaped decal on all natural gas vehicles
  - Rear of vehicle
  - Next to USDOT Number
  - Optional: front or sides of vehicle

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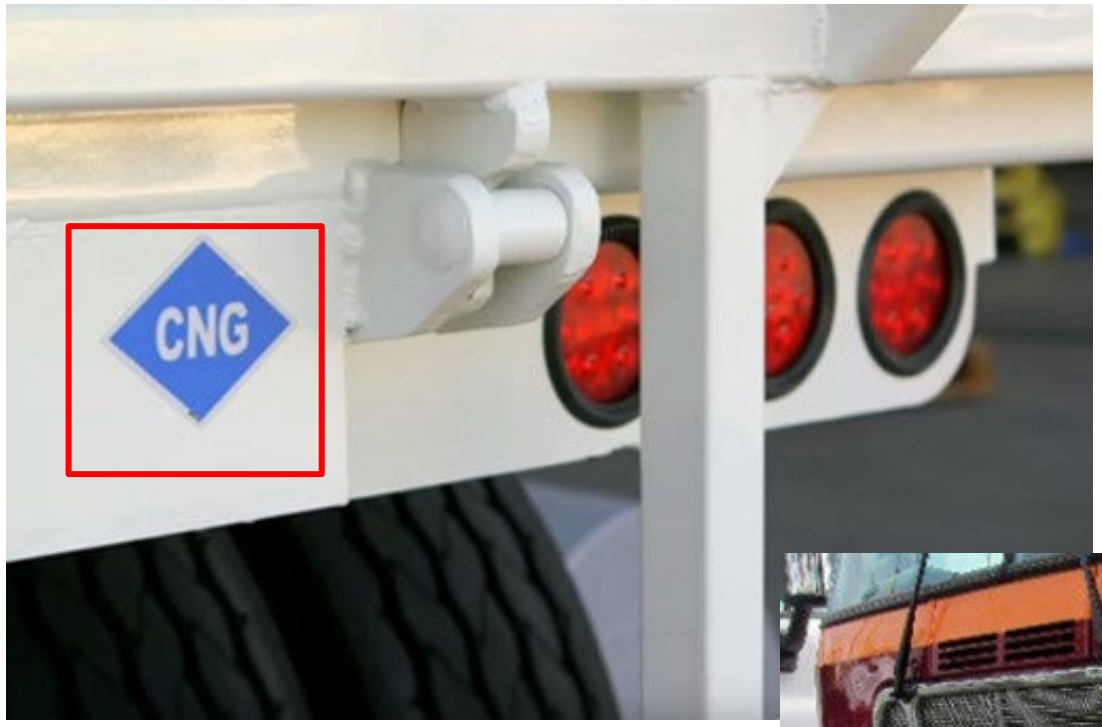
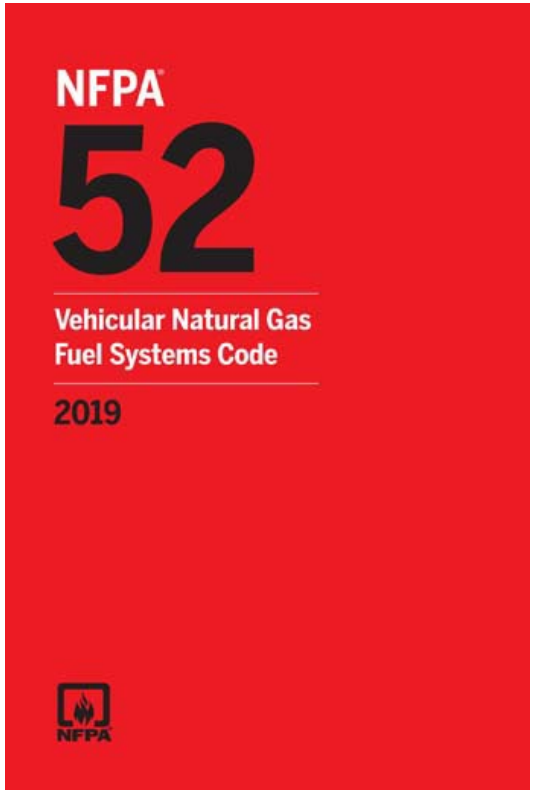
CNG Label Locations



CNG Fuel System Installation Code

- National Fire Protection Association (NFPA) 52 Vehicular Natural Gas Fuel Systems Code
  - Primary document for installation
    - Cylinders
    - Fuel System Components
  - First issued in 1984
    - Most current edition 2019
  - Revisions are not retroactive unless specifically stated in the code



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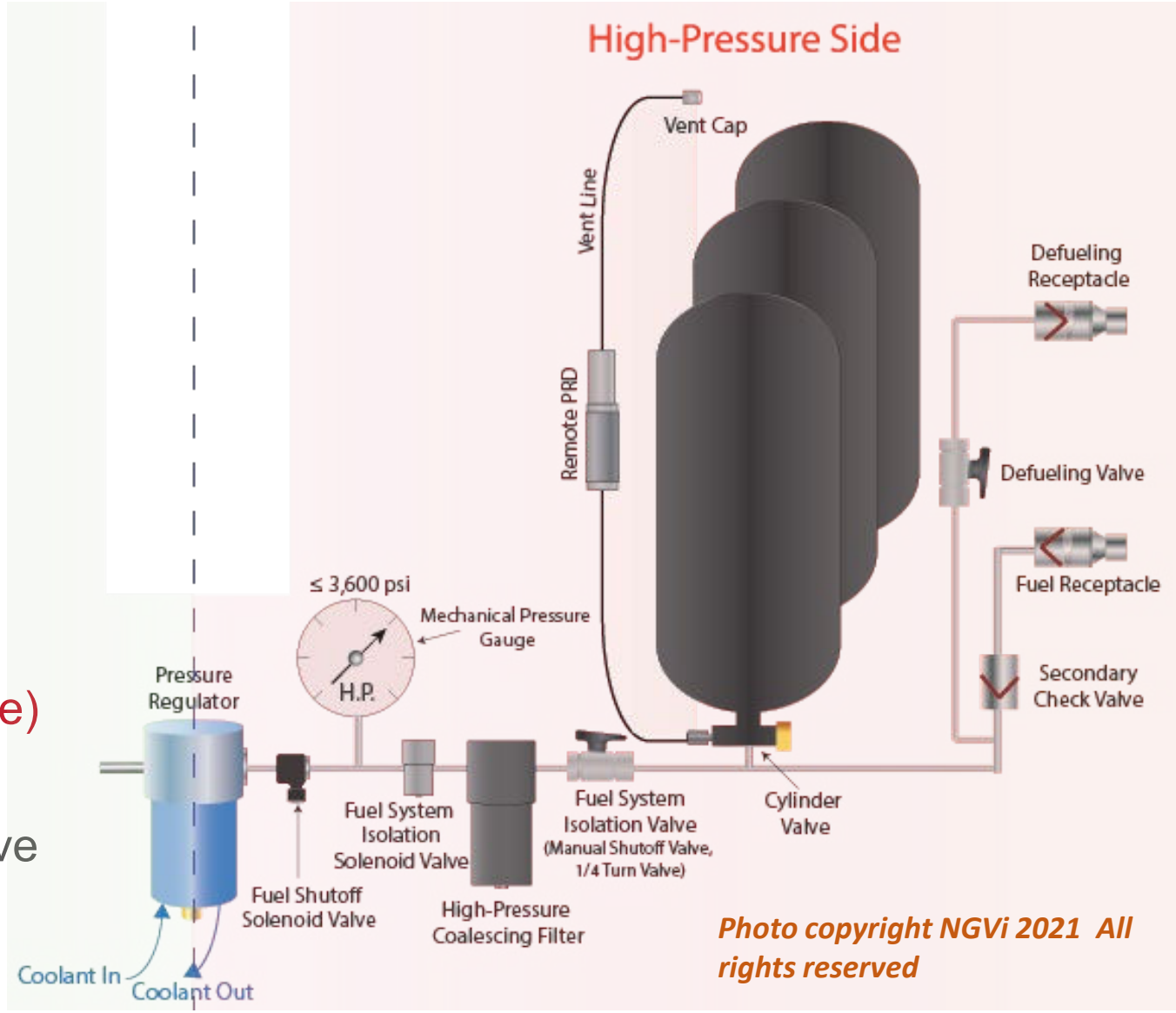
Overview of High-Pressure Components of CNG Systems

- Fuel Receptacle
- Secondary Check Valve
- Defueling System
- Fittings, Tubing and Lines
- Cylinder Valve(s)
- Cylinder(s)
- PRD(s), Vent Lines and Caps
- Fuel System Isolation Valve (Manual Shutoff Valve, ¼ Turn Valve)
- High-Pressure Coalescing Filter
- Fuel System Isolation Solenoid Valve
- Mechanical Pressure Gauge
- Fuel Shutoff Solenoid Valve
- Pressure Regulator



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Four Types of CNG Cylinders

- Type 1: All metal construction

- Type 2: Metal liner with hoop-wrap

- Type 3: Thin metal liner with continuous carbon-fiber wrap

- Type 4: Plastic liner with continuous carbon-fiber over-wrap

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CNG Pressure Relief Devices (PRDs)

- CNG cylinders are protected with one or more thermally-activated pressure relief devices (PRDs)
  - Activate between 212°F to 220°F
  - Vent system pressure
  - Designed for nominal working pressure of 3,600 psi
- Venting gas may ignite, become a jet fire, extinguish itself and re-ignite several times.
- Vehicle damage and position may modify venting gas direction.

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Eutectic Material

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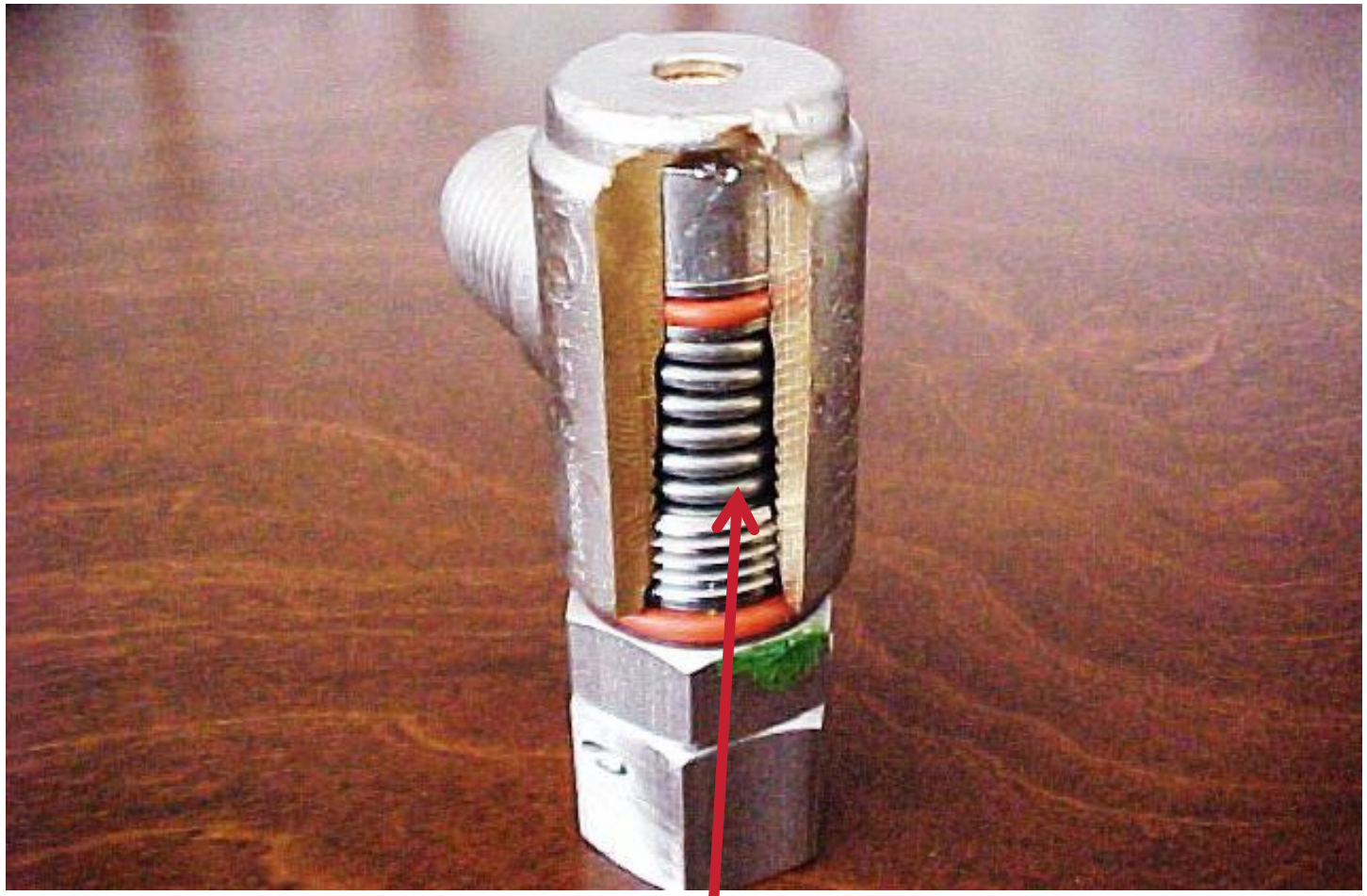
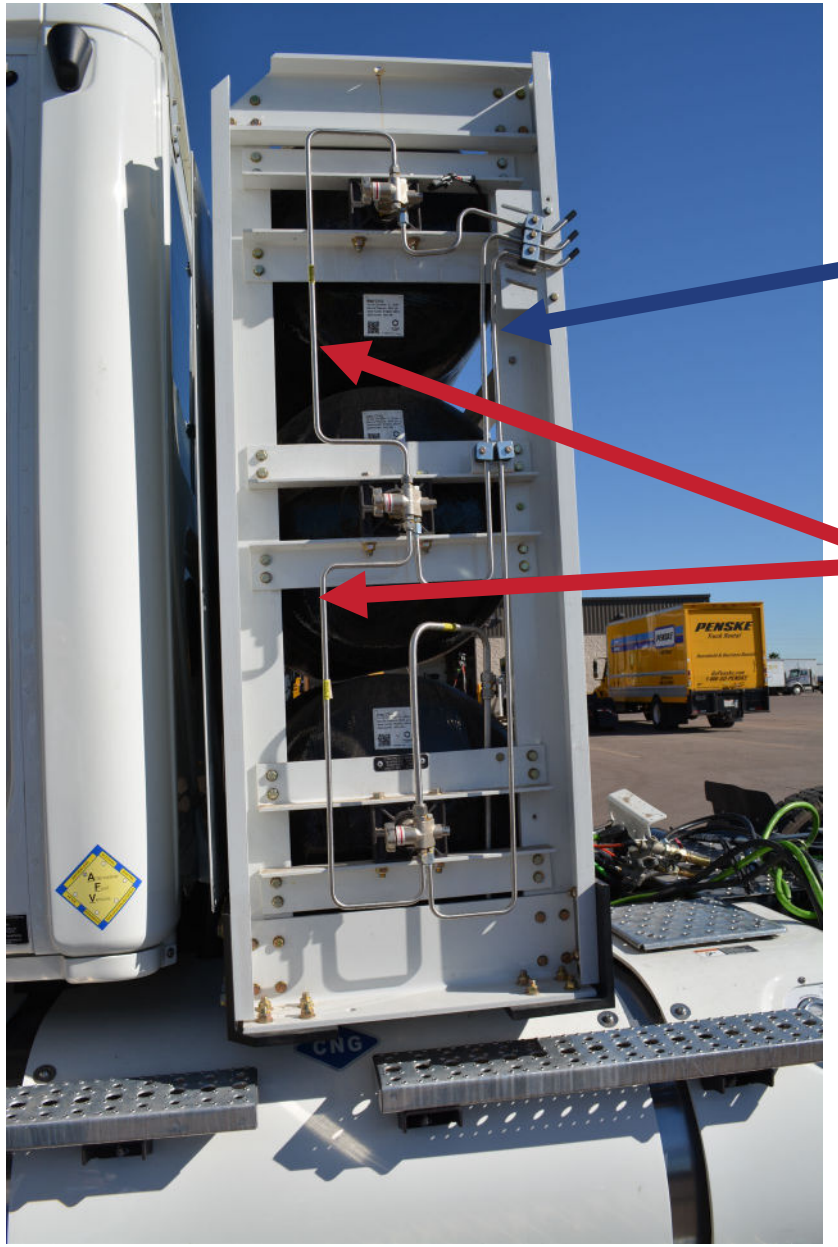


Spring Loaded Poppet

Remote PRD



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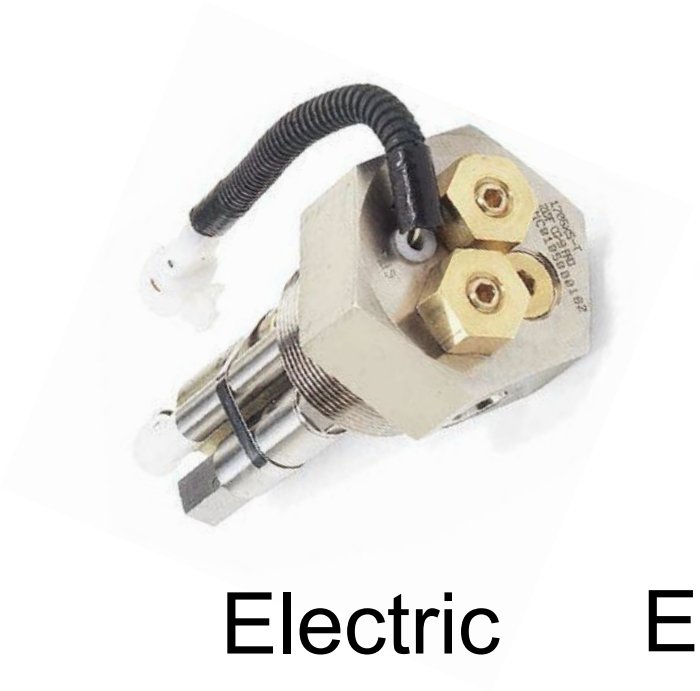
Three Types of Cylinder Valves

Function: To open or close flow of fuel into or out of the cylinder

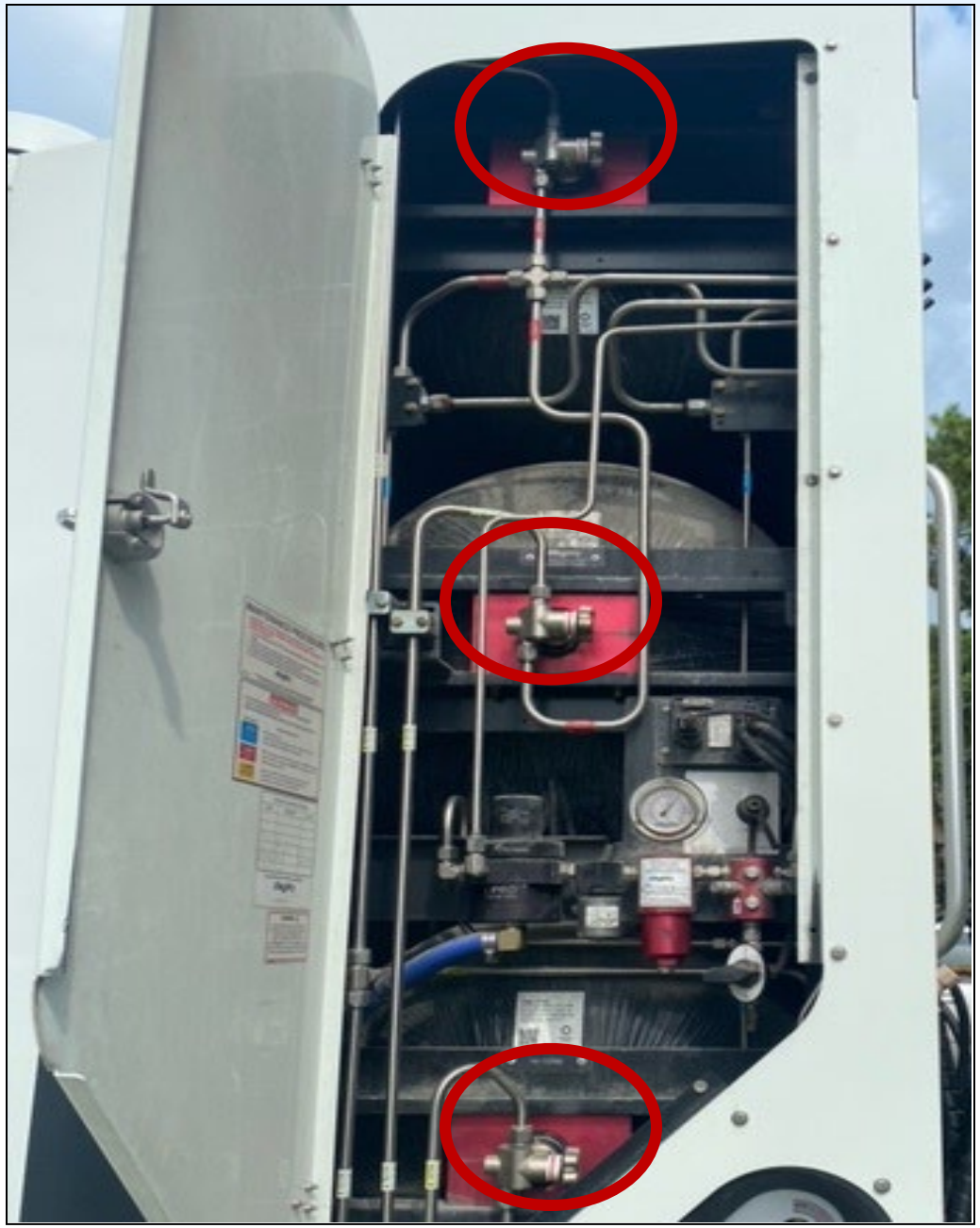
Manual



Electric

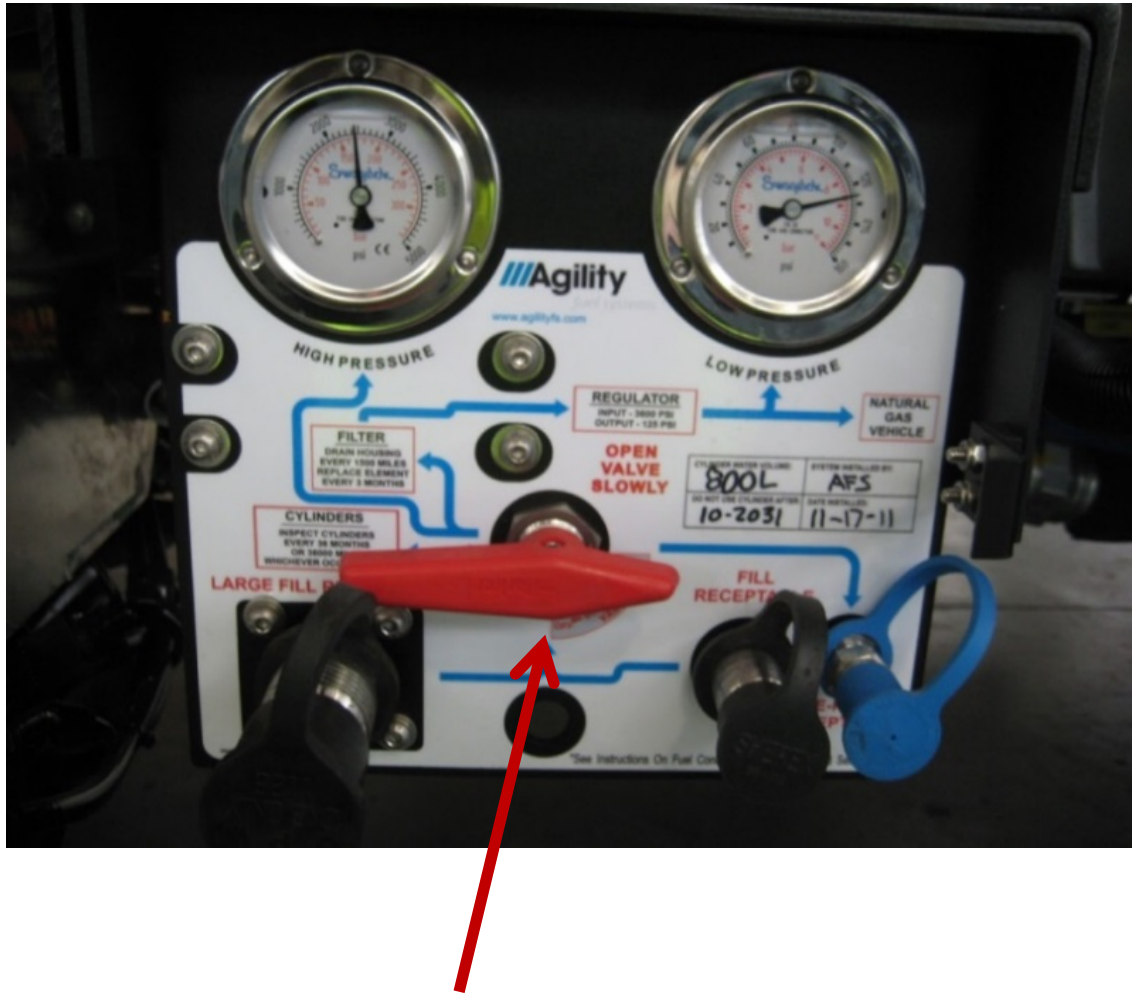
Electro-Mechanical

Cylinder Valves



Fuel System Isolation Valves

1. **Fuel System Isolation Valve**
   - ✓ Manual valve
   - ✓ Used by **first responders to shut off the high-pressure fuel flow to the engine at the scene of an accident**
2. **Fuel System Isolation Solenoid Valve**
   - ✓ Solenoid valve
   - ✓ Automatically prevents the continued flow of CNG in the event of a line break and isolates the cylinder(s) from the rest of the high-pressure fuel system



Fuel System Isolation Valve (manual valve, ¼ turn valve)

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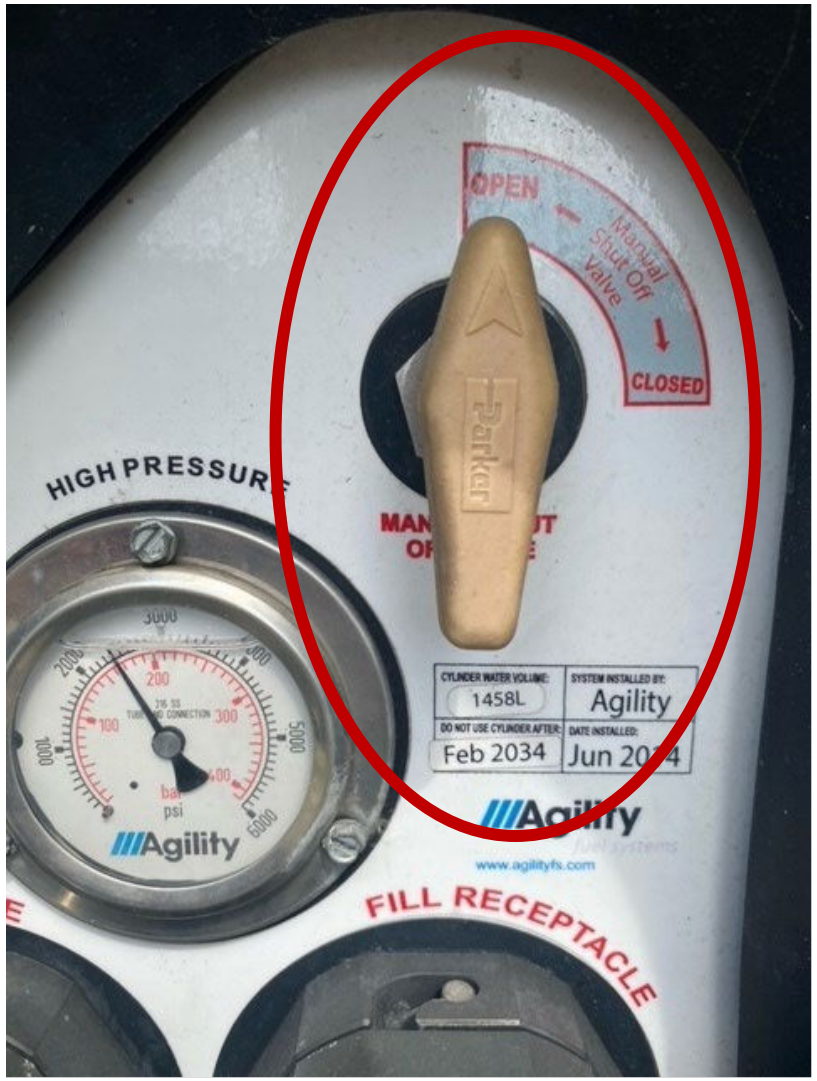

Fuel System Isolation Valve

Location of CNG Cylinders by Vehicle Type

Heavy-Duty Truck

Back of Cab and Side (Saddle) Mount

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CNG PRD venting location and direction, side mount and behind the cab systems.

CNG PRD venting location and direction, older side mount systems

Location of CNG Cylinders by Vehicle Type

Transit Bus Roof Mount

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Transit Bus with Roof Mounted Cylinders – Clamshell Open

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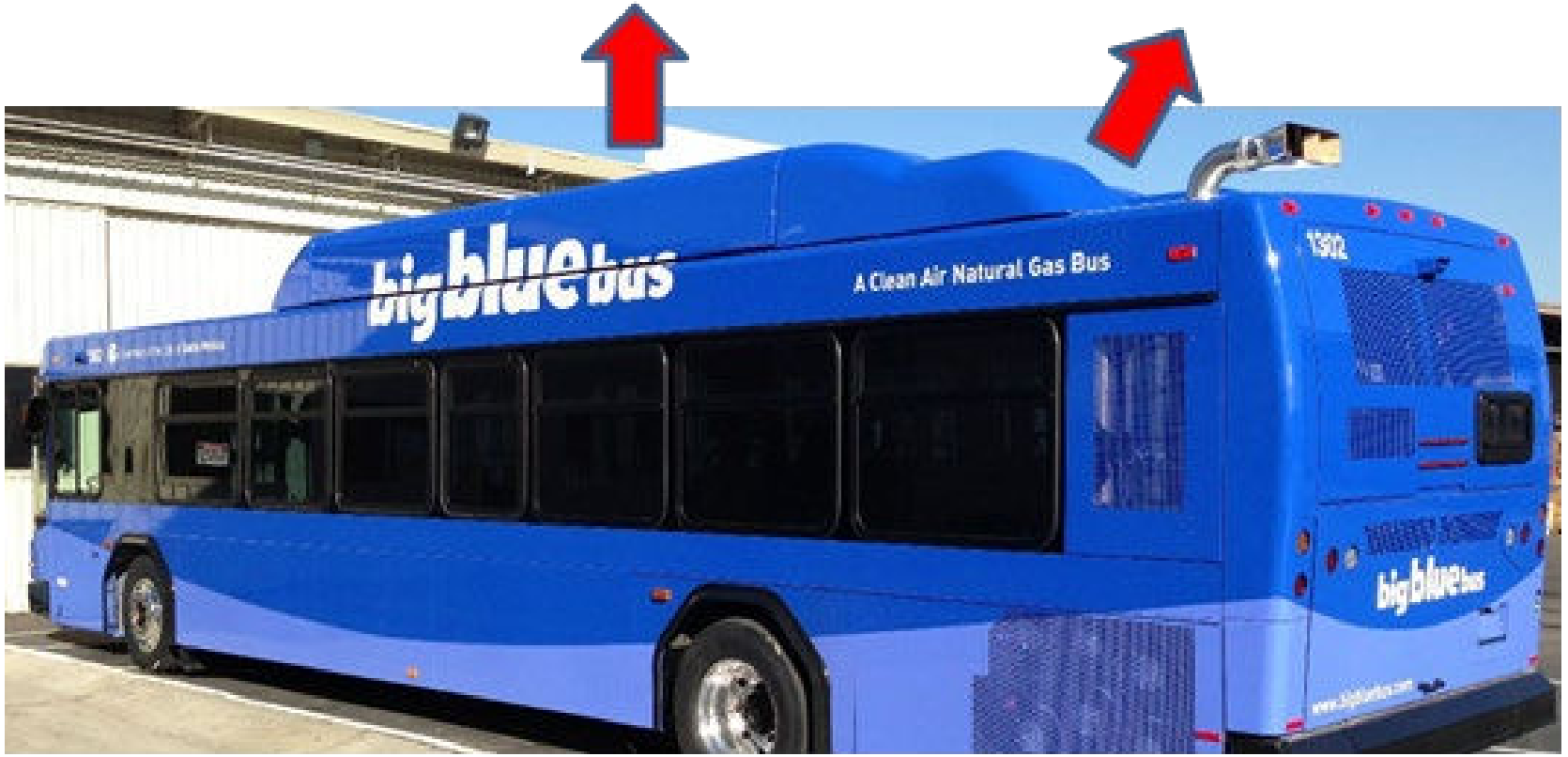
CNG PRD venting locations and directions, transit bus.



Location of CNG Cylinders by Vehicle Type

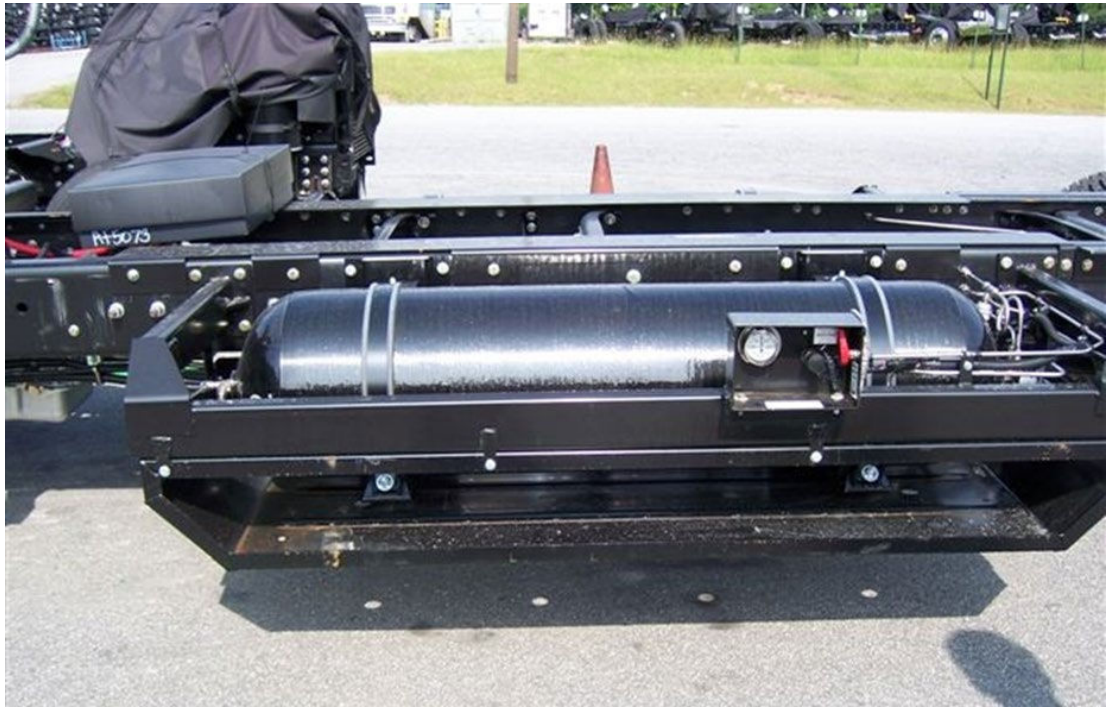
Refuse Trucks

CNG PRD venting location and direction, refuse roof mount systems.

CNG PRD venting location and direction, front of body refuse system.

Location of CNG Cylinders by Vehicle Type

Medium-Duty



CNG PRD vent tube outlet location and vent directions, medium-duty side mount system.

SIDE VIEW

REAR VIEW

Module 3: Proper CNG Vehicle Fire Response

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When a CNG Vehicle is Damaged, or a Gas Leak is Discovered

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

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.

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When a CNG Vehicle is Damaged or a Gas Leak is Discovered

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

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.

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When a CNG Vehicle is Damaged or a Gas Leak is Discovered

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

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.

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In the Event of a CNG Vehicle Fire

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).

1. Always assume a CNG cylinder is under pressure.

2. Establish a minimum safe perimeter of 80-ft to 100-ft 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.

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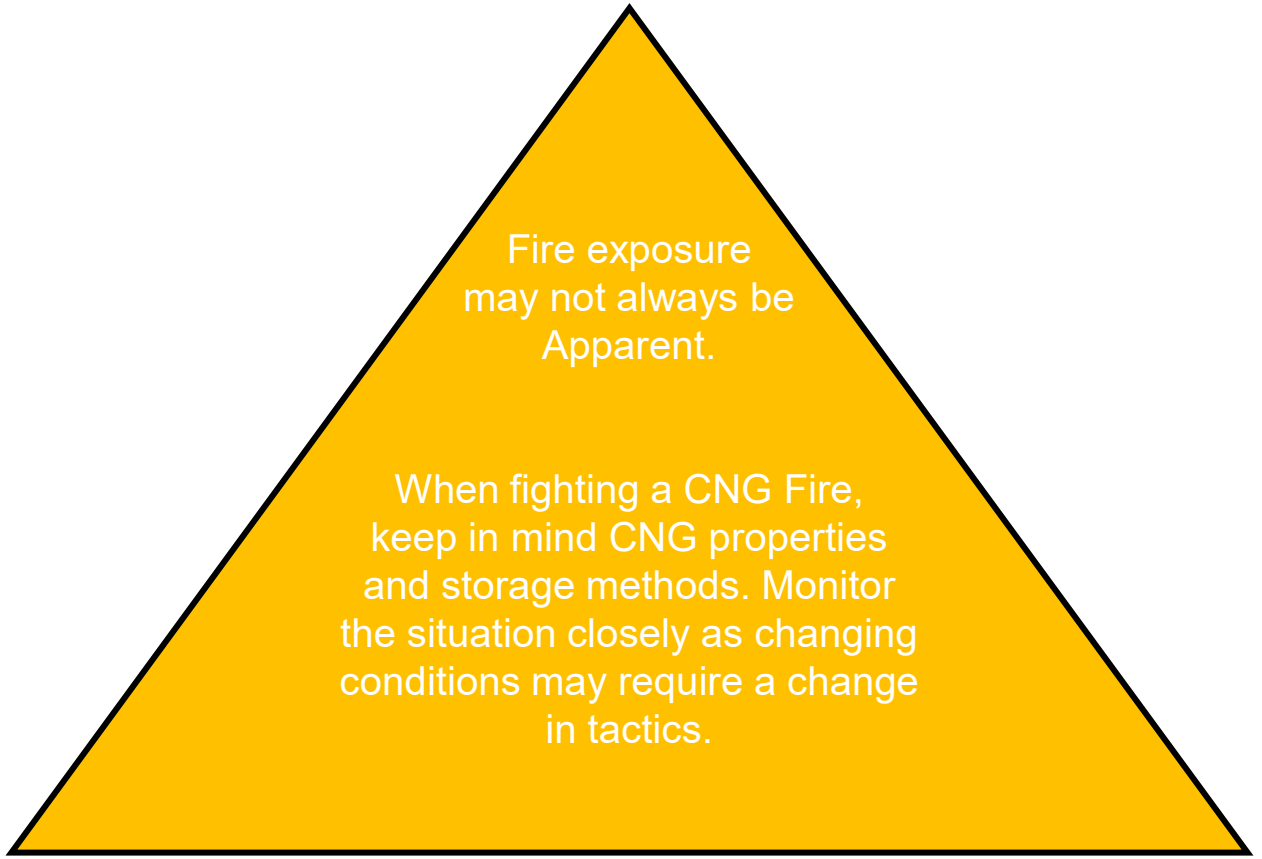
In the Event of a CNG Vehicle Fire

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).

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.**

5. Allow the fire to burn while watching for secondary hazards, such as other vehicles or structures, and protecting exposures.



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In the Event of a CNG Vehicle Fire

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).

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

7. If it is safe to do so, immediately chock vehicle wheels to prevent accidental movement.

8. When a PRD activates, the result is often a jet fire which may extinguish itself and re-ignite several times.

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

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