

SAFETY PRACTICES

for Defueling or De-Energizing
ALTERNATIVE FUEL VEHICLES



Safety Practices for Defueling or De-Energizing Alternative Fuel Vehicles

Regardless of whether your fleet vehicles are fueled/powered by natural gas, hydrogen or hydrogen fuel cells, propane, or electric batteries, there will be service or repair conditions that require them to be depressurized, completely defueled, or de-energized. There are unique safety precautions and requirements for each fuel type, as well as local environmental regulations that may affect them. This document introduces you to the protocols required for alternative fuel vehicles (AFVs) in each of these scenarios.

Key Definitions

- **High-pressure gas fuel system** – A fuel delivery system that stores and supplies gaseous fuels – such as compressed natural gas (CNG) or hydrogen (H₂) – at **high pressures** to an internal combustion engine or fuel cell.
- **Cylinder** – A high-pressure vessel designed to store and contain gases in a compressed state for various applications, including industrial, medical, and automotive use.
- **Tank** – A pressurized vessel designed to store and supply liquefied petroleum gas (LPG), commonly known as autogas, at **moderate pressures** for use in propane-powered vehicles.
- **High-Voltage Electrical System** – The electrical propulsion system in an electric or hybrid vehicle that operates at voltages significantly higher than traditional 12V or 48V automotive systems; typically ranging from 200V to over 800V.
- **Depressurizing:** The process of safely removing gaseous fuels from specific sections of the compressed gas fuel system to allow safe repairs of select high-pressure components, **not including** cylinders, valves, or pressure relief devices (PRDs). This process **does not** completely remove fuel from the fuel system.
- **Defueling:** The controlled process of safely removing all gaseous fuel from the entire compressed gas fuel system, including high-pressure cylinders or moderate-pressure tanks. It is required when fuel system components that require service, repair, or replacement cannot be isolated by valves, and includes some maintenance procedures as well as cylinder decommissioning.
- **Purging:** The process of safely removing residual gas after pressurized fuel systems, including cylinders, have been defueled. For CNG and H₂ vehicles, purging is accomplished by introducing an inert gas (e.g., nitrogen) into the cylinders. For propane vehicles, the process involves the use of a specialized vacuum pump. Both methods remove residual or unpressurized gaseous fuel after defueling to ensure zero pressure for safety.
- **De-Energizing:** The process of safely disconnecting and isolating the high-voltage (HV) electrical system of an electric vehicle to prevent accidental electrocution, short circuits, or unintended energy release.

Table 1: Processes Applicable by Alternative Fuel				
	CNG/RNG	Propane/LPG	Hydrogen	Electric
Depressurizing	X	X	X	
Defueling	X	X	X	
Purging	X	X	X	
De-Energizing				X

Safety Practices for Defueling CNG Vehicles

Determine the Reason for Defueling

Repairing or replacing certain CNG fuel system components downstream from a vehicle's cylinders may only require depressurization. Maintenance of CNG cylinders, valves, and pressure relief devices (PRDs) **always requires defueling**. Common reasons for defueling include:

- Warranty/product recall service.
- Damage to the cylinder valve or PRD.
- Leaks, or Level 2 or 3 damage to the cylinder.
- Missing manufacturer labels with no options for replacements.
- Expired cylinders.
- Cylinder/vehicle decommissioning and/or disposal.

Defueling Requirements for Equipment and Systems

Vehicle Requirements – CNG vehicles must have a defueling system with the appropriate plumbing installed by the fuel system manufacturer. All heavy-duty vehicles are required to have this system.

Be sure to check with your local air quality agency or authority having jurisdiction (AHJ) for specific requirements or restrictions.

CNG Fueling Station Requirements – Some CNG fueling stations are designed with the appropriate defueling controls to accommodate the transfer of CNG back to the station. These stations should feature a defueling panel with manufacturer instructions and controls.

Manufacturer instructions must always be followed.

Vent-to-Atmosphere Requirements – Although it's not the most environmentally friendly option, venting to the atmosphere is sometimes necessary if there are no defuel-to-station options available. Vent-to-atmosphere defueling sites must have a code-compliant vent stack, including the proper defueling nozzle, plus the ability to regulate pressure and to ground the vehicle to earth. The defueling site also requires a readily accessible fire extinguisher.

Safety Requirements

1. **Only trained technicians** should perform CNG fuel system defueling.
2. **Always locate, read, and follow** manufacturer procedures.
3. **Always defuel outdoors** to avoid fire hazards.
4. **Don't smoke or use a cell phone** during defueling.
5. **Remove all potential ignition sources** from the defueling area (e.g., power tools, cell phones, welding equipment, open-flame equipment).
6. **Wear PPE** during the defueling process, including flame-resistant clothing, safety glasses and gloves.
7. **Notify nearby personnel** that defueling is being performed.
8. **Confirm that a fire extinguisher** is available.
9. **Ground the vehicle fuel system to earth** before and during defueling.

When and How To Purge CNG Cylinders

Purging requires the introduction of an inert gas such as nitrogen to remove residual CNG from a vehicle's cylinder(s) to prevent the formation of combustible air-gas mixtures inside it/them.

- **Purging is required** when a CNG cylinder is being decommissioned for long-term storage or disposal.
- Purging is **not required** if the cylinder is **defueled for maintenance or an inspection** and will be **refueled with CNG** afterward.

WARNING: NEVER attempt to purge a CNG cylinder with shop air, as this can create an unsafe and combustible mixture of gas and air inside the cylinder.

Safety Practices for Defueling Compressed Hydrogen Vehicles

Determine the Reason for Defueling

Like CNG fuel systems, servicing certain compressed H₂ fuel system components that are downstream of the high-pressure cylinders may only require depressurization. Servicing H₂ cylinders, valves, and pressure relief devices (PRDs) **always requires defueling**. Common reasons for defueling include:

- Warranty/product recall service.
- Damage to the cylinder valve or PRD.
- Cylinder leaks, or Level 2 or 3 damage to the cylinder.
- Missing manufacturer labels with no options for replacements.
- Expired cylinders.
- Cylinder/vehicle decommissioning and/or disposal.

Defueling Requirements for Equipment and Systems

Vehicle Requirements – H₂ vehicles must have a defueling system with the appropriate plumbing installed by the fuel system manufacturer.

H₂ Fueling Station Requirements – Very few compressed H₂ fueling stations in the U.S. are designed with the appropriate defueling controls to accommodate the transfer of H₂ back to the station. Those that are should feature a defueling panel with manufacturer instructions and controls. **Manufacturer instructions must always be followed.**

Vent-to-Atmosphere Requirements – Although it's not the most environmentally friendly option, venting to the atmosphere is sometimes necessary if there are no defuel-to-station options available.

Be sure to check with your local authority having jurisdiction (AHJ) or air quality agency for specific requirements or restrictions.

Vent-to-atmosphere defueling sites **must have**:

- A code-compliant vent stack.
- A code-compliant nozzle.
- A regulator or valve to control pressure during the defueling process.
- A vehicle-to-earth ground wire.
- A working fire extinguisher.

Safety Requirements

1. **Only trained technicians** should perform compressed H₂ fuel system defueling.
2. **Always locate, read, and follow** manufacturer procedures.
3. **Always defuel outdoors** to avoid fire hazards.
4. **Don't smoke or use a cell phone** during defueling.

5. **Remove all potential ignition sources** from the defueling area (e.g., power tools, cell phones, welding equipment, open-flame equipment).
6. **Wear PPE** during the defueling process, including fire-resistant clothing, safety glasses, and gloves.
7. **Notify nearby personnel** that defueling is being performed.
8. **Ensure a fire extinguisher** is readily accessible.
9. **Ground the vehicle fuel system to earth** before and during defueling.

When and How To Purge Compressed H₂ Cylinders

Purging requires the introduction of an inert gas such as nitrogen to remove residual hydrogen from a cylinder once it has been defueled. Purging prevents the formation of combustible air-gas mixtures that could create a fire hazard.

Purging is required:

- After any defueling event, and before any repairs to a cylinder or cylinder components.
- After repairs **but before** refueling the cylinders with hydrogen. This ensures the removal of air and/or oxygen.
- When a cylinder is being decommissioned for long-term storage or disposal.

WARNING: NEVER attempt to purge a compressed H₂ cylinder with shop air, as this can create an unsafe and combustible mixture of gas and air inside the cylinder.

Safety Practices for Defueling Propane Vehicles

Determine the Reason for Defueling

Unlike CNG and compressed hydrogen, propane autogas is stored in tanks as a **liquid under moderate pressure** which transitions to a gas when released for combustion. Like CNG vehicle fuel systems, servicing certain propane fuel system components downstream of their tanks may only require depressurization. Servicing propane tanks, valves, and pressure relief devices (PRDs) **always require defueling**, also known as evacuation. Common reasons for defueling include:

- Warranty/recall service.
- Tank leaks.
- Damage to tanks or tank components (e.g., valves, PRDs).
- Required welding or structural repairs near the tank.
- Permanent vehicle disposal.

Defueling Requirements for Equipment and Systems

Vehicle Requirements – Defueling a propane vehicle requires a pre-assembled fuel transfer kit sold by the fuel system manufacturer, or a service tool kit which contains individually purchased tools identified by the manufacturer.

Liquid Evacuation Requirements – To use the liquid evacuation method for defueling propane vehicles, you must have a liquid evacuation tank or a propane tank on an existing vehicle that is empty. This process also requires a specialized pump to transfer liquid propane from the vehicle's tank to a secondary tank.

Vehicle to Flare Stack – This involves venting propane from the onboard vehicle tank to a code-compliant flare stack, where the flared gas is ignited to complete the combustion process. Because ignition is required, this procedure requires a leak check of all tubing, hoses, and fittings, as well as special safety protocols that may be required by the local authority having jurisdiction (AHJ). Be sure to investigate these protocols prior to venting, and **always follow manufacturer instructions**.

Vent-to-Atmosphere Requirements – Although it's not the most environmentally friendly option, venting to the atmosphere is sometimes necessary.

Be sure to check with your local AHJ and air quality agency for specific requirements or restrictions, as well as comply with **all manufacturer instructions**.

Safety Requirements

1. **Only trained technicians** should perform propane vehicle fuel system defueling.
2. **Always locate, read, and follow** manufacturer procedures.
3. **Always defuel outdoors** to avoid fire hazards.
4. **Don't smoke or use a cell phone** during defueling.
5. **Remove all potential ignition sources** from the defueling area.

6. **Wear PPE** during the defueling process, including flame-resistant clothing, safety glasses, and cryogenic or other propane-safe gloves.
7. **Notify nearby personnel** that defueling is being performed.
8. **Ensure a fire extinguisher** is readily accessible.
9. **Ground the vehicle fuel system to earth** before and during defueling.

When and How To Purge Propane Tanks

Purging propane tanks involves the removal of both liquid and vapor.

Purging is required:

- Before installation of any new tank.
- After service that requires opening or fully defueling the tanks.

The most effective way to purge propane tanks is to use a vacuum pump made for that purpose. When purging, you must remove both the liquid and the vapor that remains in a tank.

You can also purge with propane vapor by venting to atmosphere what's already in a tank, then filling that tank with a very small amount of propane vapor or liquid **five times in series**.

Regardless of the method used, **always follow manufacturer's instructions** for purging propane tanks.

Safety Practices When De-Energizing Battery Electric Vehicles

Battery electric vehicles (BEVs) need to be de-energized for safety during maintenance, repair, transport, or emergency situations. The process is typically referred to as **de-energizing, depowering, high-voltage (HV) system disconnection, or electrical isolation.**

Determine the Reasons for De-Energizing

Maintenance or Repair – When working on high-voltage components such as the battery, inverter, or electric motor, de-energizing is necessary to prevent electric shock.

Battery Removal or Replacement – De-energizing is required before disconnecting or replacing the high-voltage battery.

De-Energizing Requirements for Equipment, Systems, and Conditions

Electrically Safe Work Zone

- Safe, clean and dry
- Adequate lighting
- Physical barriers/barricades (e.g., cones, tape, magnetic signs)
- Safety signage
- Boundary guarding
- Alert techniques for other employees in the shop

Personal Protective Equipment

- Arc flash flame resistant clothing
- Electrical insulating gloves (standard for ASTM D120)
- Approved leather over gloves
- Safety glasses
- Face shields

Tools

- Digital Multimeter (DMM) rated for the appropriate working voltage
- Insulated hand tools (rated for the voltage on which they are used)

Safety Requirements

1. **Only technicians trained on Level 2 High-Voltage EV** should perform electric vehicle de-energizing.
2. **Always locate, read, and follow** specific manufacturer procedures. Because BEVs vary in design and safety features, it is crucial to follow the specific de-energizing instructions provided by the vehicle's manufacturer.
3. **Remove all jewelry, watches, belt buckles, or other metal or electrically conductive items from each person.**

4. **Inspect all PPE and tools** for damage or disrepair.
5. **Secure the vehicle** by chocking wheels, setting the parking brake, etc.
6. **Secure the keyless fob** (if any) outside of range.
7. **Don't smoke or use a cell phone** during de-energizing.
8. **Wear the required PPE** during the de-energizing process.
9. **Use the appropriate alert techniques to notify nearby personnel** that de-energizing is being performed.
10. **Never work alone.**

Disclaimer and Legal Notice

Defueling or de-energizing alternative fuel vehicles requires specialized training and instructions. This document is intended for summary-level, **general informational purposes only and does not replace manufacturer guidelines or professional training on specific procedures for defueling or de-energizing alternative fuel vehicles.** Never attempt to defuel or de-energize an alternative fuel vehicle unless you have received professional training and have in your possession and understand how to implement written instructions from the manufacturer.